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**Southeast Rockford
Groundwater Contamination
Site - Public Comment
Feasibility Study
Rockford, Illinois**

140911

**Prepared for:
Illinois Environmental Protection Agency**

July 1995

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Section 1



Section
One

Section 1

Introduction

Camp Dresser & McKee (CDM) has been retained by the Illinois Environmental Protection Agency (IEPA) to assist in the performance of a Remedial Investigation and Feasibility Study (RI/FS) of the Southeast Rockford Groundwater Contamination Site. This document presents the results of the FS. The Primary Area of Concern addressed by this FS is defined in Section 1.2. The purpose and organization of this FS report are presented below. The history of the Site is discussed in Section 1.3. The results of the RI are discussed in Sections 1.5 and 1.6.

1.1 Purpose and Organization of Report

Section 1 of this report presents a site description, site history, the environmental setting, the results of previous investigations, and the results of the current investigation. Section 2 of this document presents the remedial action objectives (RAOs). RAOs are site-specific, quantitative goals that define the extent of cleanup required to achieve the response objectives. The Applicable or Relevant and Appropriate Requirements (ARARs) for possible remediation activities are listed. When establishing cleanup levels under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), ARARs are evaluated as described in the *CERCLA Compliance with Other Laws Manual* (EPA 1988). The development of remedial action objectives, such as cleanup criteria and the extent of contaminated groundwater, is also detailed in Section 2.

Section 3 of this document presents the identification, screening, and evaluation of technologies and process options for the remediation of the Southeast Rockford Site. Non-site-specific response actions are identified and a summary of similar Records of Decision (RODs) and other applicable treatment technology data sources are presented. The technologies and process options are then screened and evaluated with respect to site-specific technical feasibility. Those options and technologies that are retained are then further evaluated and combined into alternatives.

Section 4 of this document provides the documentation for the development and screening of the remedial action alternatives. Developing remedial action alternatives encompasses the following steps:

- Developing RAOs
 - Establishing preliminary cleanup levels
 - Determining the area of attainment
 - Estimating the restoration time frame
- Developing Alternatives
 - Determining response actions
 - Determining process options
 - Formulating alternatives

Implicit in all the evaluations of alternatives and calculations of clean up times in this FS is the assumption that sources will be controlled. If it is technically infeasible to remediate or control all sources, cleanup of the area wide groundwater may take much longer than has been projected. Section 5 provides a detailed analysis of these alternatives. Section 6 presents the comparative analysis of the selected alternatives. This analysis entails an evaluation of the overall protectiveness and compliance with the ARARs; comparison of long-term effectiveness, contaminant reduction, implementability, and cost; and an evaluation of state and community acceptance.

1.2 Site Description

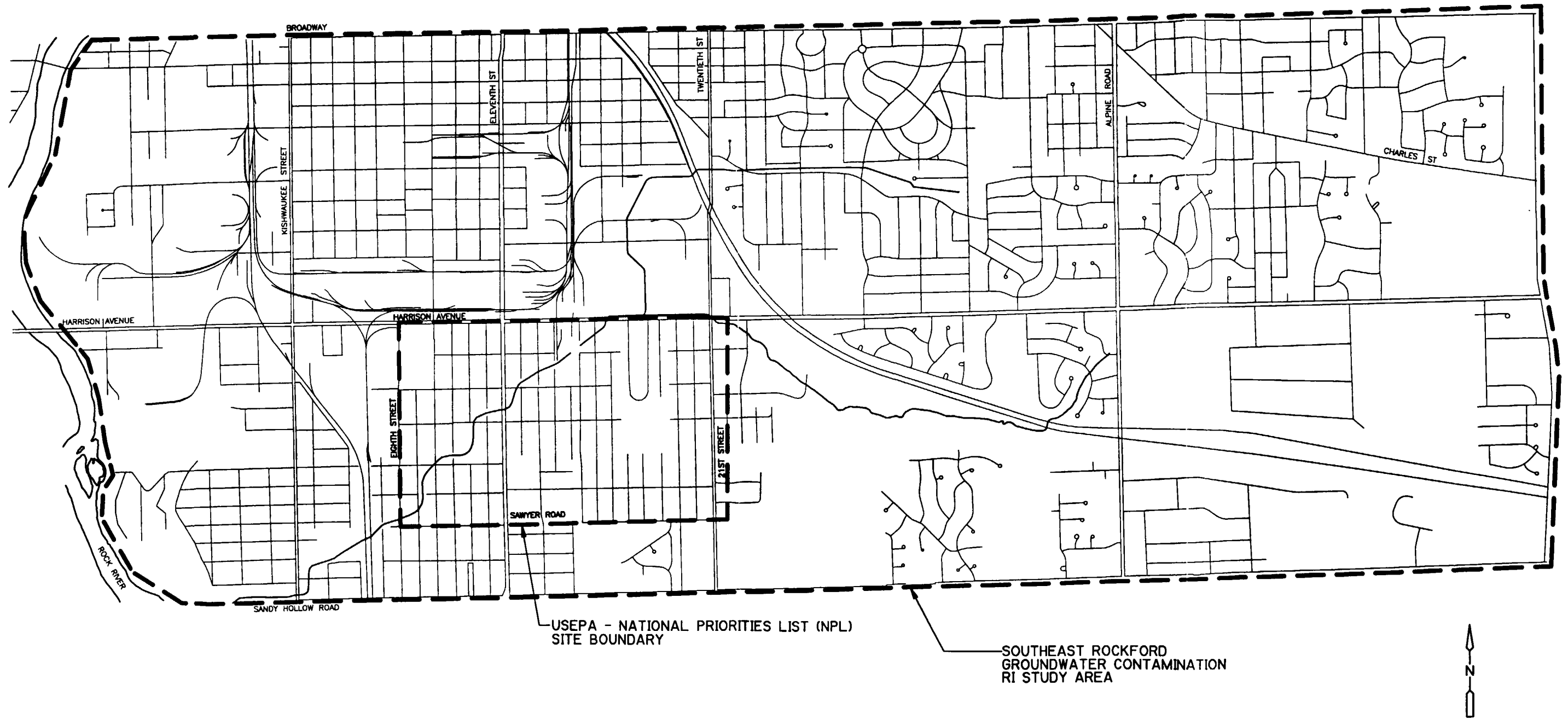
The Southeast Rockford Groundwater Contamination study area is located in southeast Rockford in Winnebago County, Illinois, and covers approximately 10 square miles. The study area is bounded by Broadway to the north, Sandy Hollow Road to the south, South Mulford Road to the east, and the Rock River to the west.

The study area is predominantly flat-lying and slopes gently westward towards the Rock River, but locally contains low-relief hilly areas. Maximum topographic relief across the study area is approximately 120 feet. A concrete-lined drainage ditch runs across the western portion of the study area and discharges to the Rock River in the southwest corner. A review of 117 Illinois Department of Public Health (IDPH) Well Construction Reports established that the majority of the residential wells that were located in the western part of the study area were screened in the 40 to 70 foot range in a sand and gravel aquifer. However, few residential wells were present in the portion of the study area east of 24th Street. Although deeper residential wells were common in the study area, no systematic distribution of the deeper wells is evident. A review of data from City of Rockford municipal wells established the local stratigraphy in deeper portions of the subsurface, and showed the penetration of low contaminant concentration to those depths.

The stratigraphy of the study area consists of bedrock with locally significant subsurface relief that is overlain by unconsolidated glacial sediments of variable thickness. The uppermost bedrock unit is generally dolomite, which forms a subsurface valley greater than 200 feet deep in the western part of the study area. Glacial sediments are thickest within this bedrock valley and thinnest on the valley flanks. The glacial sediments and the bedrock constitute two hydraulically-connected aquifers; no areally extensive aquitards have been identified in the unconsolidated aquifer.

The study area has been expanded in all directions from the boundaries, which were used to score the site for inclusion on the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL), because sampling results have indicated that the plume of contaminated groundwater extends beyond the original NPL site boundaries. The original NPL boundaries were 8th Street to the west, Sawyer Road to the south, 21st Street to the east, and Harrison Avenue to the north (Figure 1.2-1).

The Primary Area of Concern, which is the focus of this FS, is shown in Figure 1.2-2. The Primary Area of Concern is defined by the 10-part-per-billion (ppb) contour line that encompasses the largest area of contamination extending from Area 7 to north of Harrison. The 10-ppb contour line for total chlorinated volatile organic compounds (VOCs) has been derived



SOUTHEAST ROCKFORD
GROUNDWATER CONTAMINATION STUDY

NPL SITE BOUNDARY



environmental engineers, scientists,
planners, & management consultants

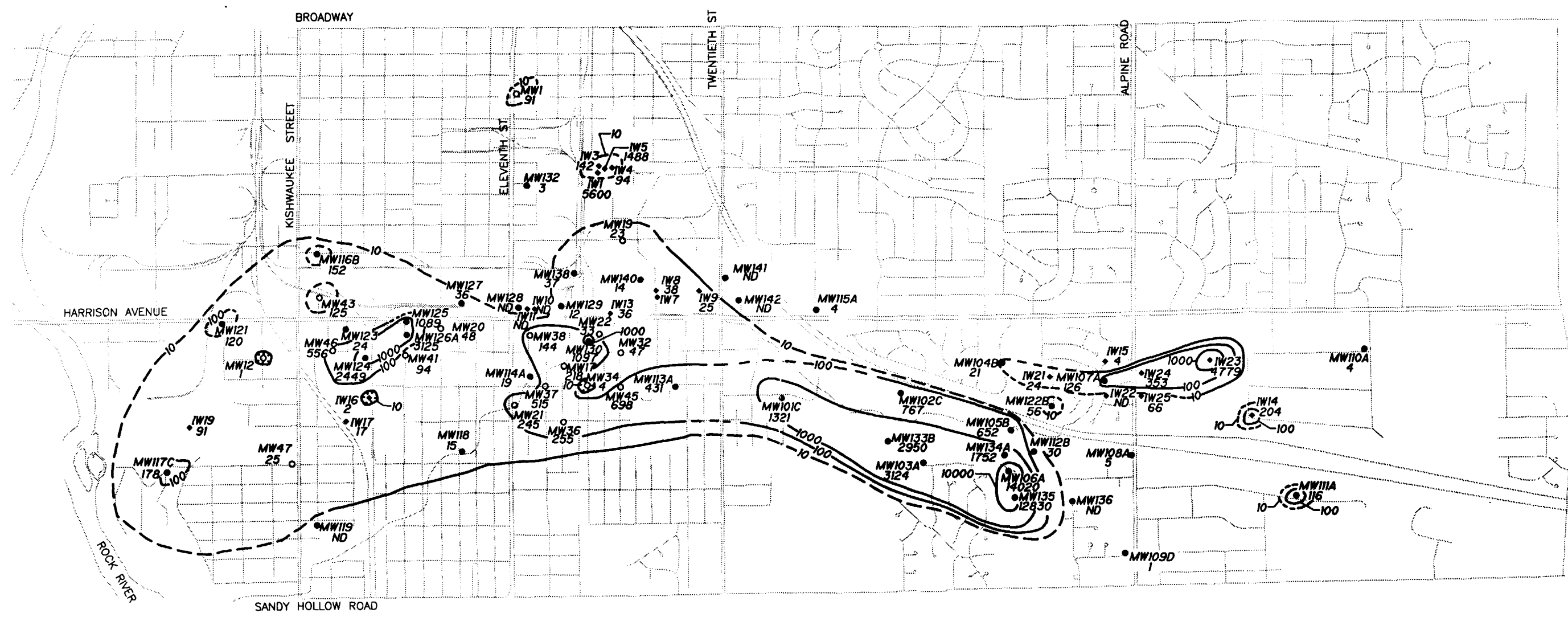
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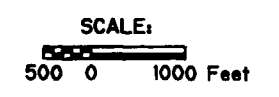
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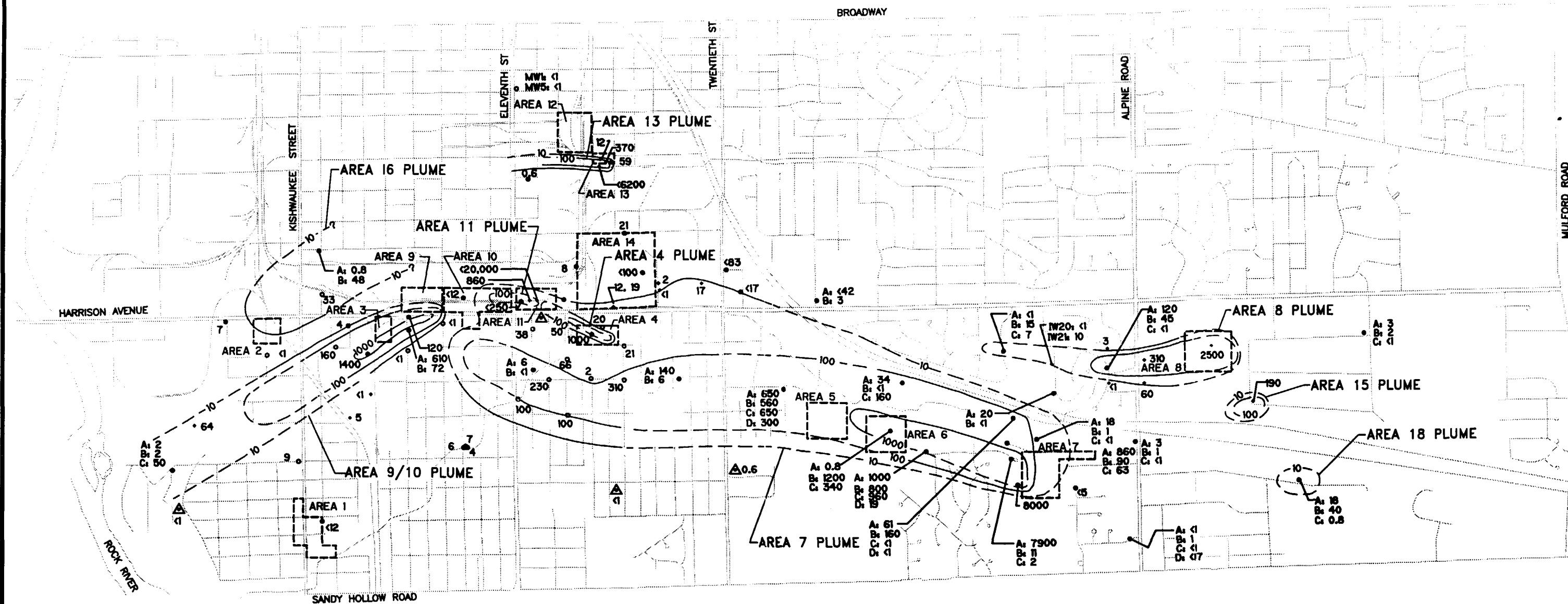
LEGEND:

- MW102 ISWS MONITORING WELL
- MW101 CDM/IEPA MONITORING WELL OR WELL NEST; LETTER SUFFIX INDICATES SPECIFIC WELL OF A WELL NEST
- ◆ IW14 INDUSTRIAL MONITORING WELL OR SUPPLY WELL
- 100- TOTAL CHLORINATED VOC CONTOUR (ug/L), DASHED WHERE INFERRED
MAXIMUM VALUE SHOWN FOR NESTED WELLS
- ND CONCENTRATION BELOW DETECTION LIMITS



SOUTHEAST ROCKFORD
GROUNDWATER CONTAMINATION STUDY
PRIMARY AREA OF CONCERN
DEFINED BY 10 ppb CONTOUR

Figure No. 1.2-2

**NOTE:**

CONTOURS ARE BASED ON MAXIMUM TCA CONCENTRATIONS AT A GIVEN WELL NEST.

LEGEND:

- 21 ISWS MONITORING WELL WITH TCA CONCENTRATION, ppb
- A1 140 B1 6 CDM/EPA MONITORING WELL NEST OR WELL WITH TCA CONCENTRATION, ppb; LETTER INDICATES SPECIFIC WELL OF A WELL NEST
- 60 INDUSTRIAL SUPPLY WELL OR MONITORING WELL WITH TCA CONCENTRATION, ppb
- △ <1 SELECTED RESIDENTIAL WELL SAMPLING LOCATION (RESIDENTIAL WELL LOCATIONS, ADDRESSES AND COMPLETE RESULTS ARE GIVEN IN SECTION 6)
- 100- CONTOUR OF MAXIMUM TCA CONCENTRATION AT WELL NEST OR WELL LOCATION; DASHED WHERE INFERRED
- SOURCE AREA



SCALE:
500 0 1000 Feet

SOUTHEAST ROCKFORD
GROUNDWATER CONTAMINATION STUDY

SOURCE AREAS AND
PLUME LOCATIONS

CDM

environmental engineers, scientists,
planners, & management consultants

from the results of the 1993 Phase II groundwater sampling. The extent of contaminated groundwater to be addressed by this FS is that located within the Primary Area of Concern.

1.3 Site History

Groundwater contamination by VOCs was initially discovered by the Rockford Water Utility in 1981. Four municipal wells in Southeast Rockford were taken out of service in December 1981 due to the contamination. In 1982, the city discovered that additional wells were contaminated and subsequently closed down these wells. Within the study area, Municipal Unit Well 35, located near Ken Rock Playground (Bildahl Street and Reed Avenue), was found to be contaminated during a routine sampling of the well in 1984; the well was tested for 33 priority pollutants and several VOCs were detected. Because contaminants were present at levels above the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL), the well was taken out of service. During the removal action conducted by EPA (July 1991 to November 1992), a granular activated carbon treatment system was installed at Municipal Unit Well 35. The well is now pumped periodically based on service demand.

IEPA discovered that VOCs were present in Southeast Rockford's private wells in 1984 as a result of a report that plating wastes were being illegally disposed in a well located at 2613 South 11th Street. In October 1984, IDPH initiated an investigation that involved sampling 49 private wells in the vicinity of this well. While the investigation did not find significant levels of contaminants commonly associated with plating wastes, it did report high levels of chlorinated solvents, which were also detected in the City of Rockford's municipal well. IDPH conducted four separate sampling investigations involving residential wells in the Southeast Rockford area: 49 samples were collected in 1984, 43 samples in 1985, 17 in 1988, and 267 in 1989. For the most part, sample locations varied during the separate sampling investigations; however, in some cases, wells were sampled more than once.

In 1986, the Illinois State Water Survey (ISWS) completed a project that involved a regional characterization of groundwater quality in Rockford. The study indicated that groundwater samples from public and private wells in the Southeast Rockford area contained significant concentrations of VOCs. Seven private well sites sampled in the Southeast Rockford area as part of the study contained greater than 10 µg/L total VOCs; five of those seven contained greater than 100 µg/L total VOCs. One of the private wells containing greater than 100 µg/L total VOCs was located near the Rock River (Wehrmann 1988).

As a result of sampling events by state and federal agencies, the Southeast Rockford Site was proposed for inclusion on the NPL in June 1988 and was added to the NPL in March 1989 as a state-lead, federally-funded Superfund site. Throughout 1989, the EPA Technical Assistance Team (TAT) sampled 112 residential wells in the Southeast Rockford area and tested for the following abbreviated list of VOCs:

- Trichloroethene (TCE)
- *cis*-1,2-Dichloroethene (*cis*-1,2-DCE)
- 1,2-Dichloroethane (1,2-DCA)
- 1,1,1-Trichloroethane (1,1,1-TCA)

- *trans*-1,2-Dichloroethene (*trans*-1,2-DCE)
- 1,1-Dichloroethane (1,1-DCA)

In August 1989, EPA initiated a time critical removal action under which bottled water was offered as a temporary measure to residents whose well water analysis results revealed VOC levels greater than or equal to 25 percent of the Removal Action Level (RAL). The RALs are equal to one-half of the concentration of a noncarcinogenic parameter that results in a Hazard Index of 1. In mid-December 1989, these residences were equipped with carbon filters as an intermediate solution to the problem. EPA ultimately extended water mains and provided hookups to municipal water supply to 293 residences between June and November 1990.

During June 1990, CDM, under the direction of IEPA, conducted a groundwater sampling investigation of 117 private wells in Southeast Rockford as part of the Operable Unit Remedial Investigation. The objective of this sampling was to determine if any homes had wells with levels of VOCs below the time critical removal action cutoff (25 percent of the RAL), but above MCLs. The values of the RALs that guided the hook-ups to the Utility System are presented in Table 1.2-1. The IEPA sampling revealed an additional 243 homes that required connection to Rockford's Water Utility System (Utility System).

The Proposed Plan for this Operable Unit was released to the public in March 1991 and included the connection of the affected homes to the municipal supply and the construction of a granular activated carbon (GAC) treatment facility for Municipal Unit Well 35. The Proposed Plan was finalized in the ROD with minor modifications. The ROD was signed in June 1991.

The Operable Unit was established under the removal program in order to complete construction during 1991. By November 1991, 264 homes were connected to the Utility System. By November 1992, the GAC unit was operational and available to assure sufficient service capacity for the area.

From May to October 1991, CDM and its subcontractors, under the direction of IEPA, conducted the Phase I Remedial Investigation. In Phase I, the study area was expanded from the original NPL site boundaries to an area of approximately five square miles. The Phase I area was bounded on the north by Harrison Avenue, on the south by Sandy Hollow Road, Wendy Lane to the east, and the Rock River to the west. Phase I activities included a 225-point soil gas survey, installation of 33 monitoring wells at 11 locations, hydraulic conductivity testing, sampling and analysis of the 33 Phase I wells, 19 ISWS wells and 16 industrial wells, and subsurface soil sampling during drilling. The Phase I study was designed to define the nature and distribution of groundwater contamination, define local geology and hydrogeology, and to gain preliminary information on potential contaminant source areas.

The result of the Phase I investigation indicated two areas of groundwater contamination of volatile organic compounds, including one area located near the industrial facility southeast of the intersection of Harrison Avenue and Alpine Road, and a larger area near and downgradient (west-northwest) from well nest MW106. Near the downgradient extent of this plume, several plumes, possibly related in part to the larger plume, were identified west and southwest of MW20. Figure 1.3-1 shows the primary source areas on the Site as well as the location of the major plumes. 1,1,1-TCA is the contaminant depicted in Figure 1.3-1.

Table 1.2-1
Removal Action Levels
(µg/ l)

Chemical	RAL
1,1,1-TCA	650
1,1-DCE	158
PCE	175
TCE	110
<i>cis</i> -1,2-DCE	31
1,1-DCA	400
<i>trans</i> -1,2-DCE	60

Based on elevated VOC concentrations in soil gas or groundwater, eight potential source areas were also identified during the Phase I investigation, as follows: (1) upgradient from well nest MW106 (Area 7); (2) upgradient from well nest MW101 (Areas 5 and 6); (3) at the industrial facility southeast of Harrison Avenue and Alpine Road (Area 8); and (4) several discrete locations in industrial areas in the western part of the study area (Areas 1 through 4). At the conclusion of the Phase I field activities a Technical Memorandum was prepared.

Subsequent to Phase I, CDM examined information on industrial operations and defined additional potential source areas that were proposed for investigation during Phase II. These areas were identified as Areas 9 through 14. The information examined included IEPA files from the Rockford office, and information on facility practices provided to EPA by industrial enterprises under an ongoing enforcement action.

In March 1992, EPA and IEPA conducted a preliminary geophysical survey of Potential Source Areas 6 and 7 as identified by the Phase I Technical Memorandum. This survey was prompted by reports of illegal dumping in Area 7 and the results of groundwater samples collected during Phase I from MW106, 108, and 109.

Based on the preliminary results of the March 1992 survey, a more detailed investigation of Area 7 was performed by CDM and EPA in May 1992. The investigation included a terrain conductivity survey, a ground-penetrating radar survey, and a soil gas survey. Survey results indicated the presence of buried magnetic anomalies and VOCs in the soil gas, primarily in the area of Ekberg Park.

The Phase II scoping activities began in the summer of 1992. The objectives of Phase II included: (1) filling data gaps identified in Phase I; (2) providing sufficient information on potential source areas to allow an evaluation of need for future work; (3) gathering sufficient information to expand the groundwater model; and (4) gathering sufficient information to support a risk assessment and feasibility study for the groundwater.

The Phase II field activities were conducted from January 1993 to January 1994. The results of the Phase II field activities are presented in detail in the RI report and are summarized in Section 1.5.

1.4 Environmental Setting

This section presents the environmental setting of the region and the Southeast Rockford Site. The physiography, geology, hydrology, hydrogeology, and land use are summarized. These topics are presented in more detail in the RI report, and are only summarized in this report.

1.4.1 Physiography

The City of Rockford is located in the southwestern portion of Winnebago County, Illinois. The County lies within the Rock River Hill Country physiographic province and is marked by rolling topography with elevations ranging from about 700 feet mean sea level (msl) in Rockford to over 900 feet msl in other parts of the county. Several rivers and creeks are found in the county's watersheds, most of which drain into the Rock River, which flows in a predominantly north to south direction, ultimately emptying into the Mississippi River.

1.4.2 Geology

The geology of the study area generally comprises an eroded bedrock surface of considerable relief overlain by unconsolidated glacial sediments of variable thickness. The buried bedrock surface represents preglacial valleys and uplands. The Rock Bedrock Valley, the precursor of the present-day Rock River, runs north-south across the western portion of the study area. An east-west tributary valley to the Rock Bedrock Valley runs through the study area.

Three bedrock units of Ordovician age are present at the bedrock surface in the study area: the Galena, Platteville, and Ancell Groups. The Ancell Group consists of the St. Peter Sandstone and the overlying Glenwood Formation. The Galena and Platteville Groups are dolomite bedrock units characterized by porous or vuggy zones near the bedrock surface. Near MW114 and at locations to the west, these units are eroded, leaving the underlying Ancell Group exposed at the bedrock surface. The Glenwood is characterized by variable lithology consisting of dolomitic sandstone and an upper shale unit. This shale was observed in one of the two boreholes that penetrated the St. Peter Sandstone. The St. Peter Sandstone was observed to be a white quartz sandstone.

The unconsolidated sediments in the eastern portion of the study area (east of about 24th Street) are complexly interbedded glacial till, moraine, and outwash deposits consisting of sands, silts, and clays with silts and clays representing approximately 30 percent of the unconsolidated sediments. The unconsolidated sediments in the western portion of the study area are predominantly sand with some gravel and discontinuous silt and clay layers.

1.4.3 Hydrogeology

Groundwater aquifers of concern are found in the following three units within the study area: the unconsolidated glacial sediments (unconsolidated aquifer), the Galena-Platteville dolomite (dolomite aquifer), and the St. Peter Sandstone (sandstone aquifer). The unconsolidated aquifer generally overlies the dolomite aquifer in the eastern half of the study area and overlies the sandstone aquifer in the western half. Groundwater flow direction in the unconsolidated and dolomite aquifers is generally to the west. The flow pattern in the sandstone aquifer is influenced by pumpage from municipal wells.

The unconsolidated aquifer is hydraulically connected to the dolomite aquifer in the east and to the sandstone aquifer in the west. These bedrock units are exposed at the bedrock surface in these areas, with no confining layers present between bedrock and unconsolidated units.

Large downward hydraulic gradients exist across the Glenwood Formation in the eastern portion of the study area, where hydraulic heads in the St. Peter (stratigraphically below the Glenwood) are approximately 100 feet below those in the Galena and Platteville Groups (above the Glenwood). This pattern indicates that the Glenwood acts as a confining layer and is a barrier to downward flow in this area, and shows the influence of municipal pumping wells open to the St. Peter.

The mean horizontal hydraulic conductivities in the unconsolidated aquifer, as measured by slug tests, were approximately 4.0×10^{-5} ft/sec for both the eastern and western portion of the study area. The mean conductivity of the dolomite aquifer was slightly lower at 3.0×10^{-5} ft/sec. The

mean conductivity of the sandstone aquifer was greater than that of either the dolomite or unconsolidated aquifers, at 1.1×10^{-4} ft/sec.

1.4.4 Land Use

The study area is predominantly an urban and suburban residential area, which includes scattered industrial, agricultural, retail, and commercial operations. A small industrial park is located in the central portion of the study area in the vicinity of Laude Drive and 24th Street. Other industrial areas are situated in the vicinity of Harrison Avenue and Alpine Road, Sandy Hollow Road and Alpine Road, near the Rock River in the northwest, and elsewhere in the study area. Agricultural areas are present in the southeastern portion of the study area, as well as areas to the east and south of the study area.

1.5 Chemicals of Concern

VOCs are the primary groundwater contaminants in the shallow aquifers in the study area, including chlorinated VOCs, BETX (benzene, ethylbenzene, toluene, xylene) compounds, and ketones. Other contaminants are found only locally, and then primarily only in soils, including certain PAHs (polynuclear aromatic hydrocarbons), pesticides, PCBs (polychlorinated biphenyls), heavy metals, and cyanide. Chlorinated VOCs are the most frequently detected and most abundant contaminants in groundwater; in order of decreasing abundance, these contaminants are 1,1,1-TCA, TCE, 1,2-DCE, 1,1-DCA, 1,1-DCE, and tetrachloroethene (PCE). A complete summary of all compounds detected, including range and frequency of detection, can be found in Tables 4-8 and 4-9 of the RI.

1.6 Extent and Volume of Contamination

1.6.1 Contaminant Plume Characterization

The chlorinated organic compounds 1,1,1-TCA, TCE, PCE, 1,1-DCA, 1,1-DCE, and 1,2-DCE form relatively extensive groundwater contaminant plumes in the study area, extending up to about two miles long. The distribution of these compounds in the groundwater is such that 11 distinct plumes can be defined in the study area. The Area 4, Area 7, Area 8, and Area 9/10 plumes are relatively well-defined, while others are either based on only several wells, or plume boundaries are not well established (the other identified plumes are the Area 11, Area 13, Area 15, Area 16, Area 17, Area 18, and Area 19 plumes). 1,1,1-TCA plume locations are shown in Figure 1.3-1 for reference. The RI contains figures depicting the specific plume locations for each of the COCs.

The Area 7 plume is the largest and best characterized contaminant plume in the study area; it extends for a length of about two miles, and has a width of about 1,500 feet at the 100 ppb contour for 1,1,1-TCA. Downgradient (west) of MW101, this plume affected residential wells across a wide area, necessitating hookups of these residences to municipal water supplies. This plume begins in Area 7 and gradually migrates from the shallow portion of the aquifer system to maximum depths of about 200 feet between MW103 and MW101. Downgradient of MW101, the Area 7 plume probably stays at about the same elevation; penetration of the Area 7 plume into deeper units (Glenwood Formation or below) is likely slight.

The Area 7 plume shows coherent behavior regarding relative contaminant abundances. In general, across this plume, the ratios of the major contaminants to 1,1,1-TCA (the most abundant

contaminant) fall within a limited range. These ratios appear to reflect the composition of the Area 7 contaminant source, based on comparison of groundwater results to subsurface soil and soil gas sampling results; this is also supported by the fact that the contaminant ratios in other plumes tend to fall within different ranges (e.g., lower TCE/1,1,1-TCA ratios in Areas 4 and 8 plumes than in the Area 7 plume; higher TCE/1,1,1-TCA ratios in Area 16 plume). The Area 7 plume also behaves coherently in that contaminant concentrations decline steadily in the downgradient direction (west-northwest), due to the effects of dispersion. Taken together, these patterns support the concept that the Area 7 plume originates from a single, large contaminant source near the east end of Balsam Lane (at Area 7).

The Area 8 contaminant plume has the second-highest concentrations of chlorinated VOCs in the study area. This plume appears to be about 4,000 feet long and 500 feet wide, and is found at relatively shallow (less than about 100 feet) in both unconsolidated and bedrock aquifers. The Area 8 plume has its own distinctive fingerprint, with a low ratio of TCE to 1,1,1-TCA, and relatively high proportions of 1,1-DCE compared to the other plumes. These patterns have held from Phase I (when sampling in the Area 8 plume was more extensive) to Phase II, and across the entire plume, allowing discrimination of the Area 8 plume from the Area 7 plume located a short distance to the south.

The Area 9/10 contaminant plume has the third-highest concentrations of chlorinated VOCs in the study area. This plume is about 800 feet wide and at least 1,500 feet long, though the total length is unknown; it is probably confined to the unconsolidated aquifer. The plume also has a somewhat variable composition chemically: the upgradient portion has low ratios of TCE to 1,1,1-TCA and high proportions of biodegradation daughter products. While two downgradient wells have high TCE/1,1,1-TCA and/or high PCE. It is not known whether these differences reflect variability within the same plume, or if two separate plumes are present.

It is likely that the Area 9/10 plume signals the presence of a contaminant source a short distance upgradient (probably near the southern boundary between Areas 9 and 10), based on the abundance of PCE and total chlorinated VOCs relative to wells upgradient. The presence of a high proportion of degradation daughter products in this plume is most likely due to the presence of high concentrations of aromatic compounds (toluene and xylene) that have apparently fostered biodegradation.

The Area 4 contaminant plume is considerably smaller than those discussed above, being about 300 by 1,200 feet. This plume has a distinctive contaminant fingerprint based on the fact that 1,1,1-TCA constitutes about 95 percent of total detected VOCs. The high 1,1,1-TCA fingerprint is replicated in both soil gas and subsurface soil samples in and adjacent to Area 4. The correspondence of sampling results from various media suggests that the Area 4 plume derives from a single source located in the upgradient portion of Area 4.

The Area 11 contaminant plume consists primarily of aromatic compounds (ethylbenzene, toluene, and xylene [ETX]), though elevated concentrations (up to 2,900 ppb) of several chlorinated VOCs are also present. As defined by the presence of the aromatic compounds, the Area 11 plume is about 4,000 feet long. The plume of chlorinated VOCs is shorter, perhaps less than 1,000 feet; the reason for this may be that the chlorinated VOCs may not have been present in the source soils for as long.

Of the other contaminated areas at the study area, the Area 15, Area 18, and Area 19 plumes contain relatively low (less than 300 ppb total VOCs) contaminant concentrations; these plumes also do not appear to be areally extensive (roughly 1,000 feet). The Area 16 and Area 17 plumes also contain low contaminant concentrations; however, the lateral and longitudinal extent of these plumes are not known. Higher VOC concentrations (both chlorinated and non-chlorinated) are present in the Area 13 plume; however, the extent of this plume is also unknown.

There are scattered areas with elevated contaminant concentrations in groundwater, such as several occurrences of low-concentration VOCs (<100 ppb) in areas with no known source, but which could have been locations of disposal not previously identified. These patterns show that plumes cannot be connected on the basis of low-concentration hits only. For example, the Area 8 and Area 7 plumes cannot be connected based on low concentrations found in MW122A. The contaminant fingerprint at that well is more characteristic of the Area 7 plume, and other Area 7-type contamination could very easily exist outside the limited zones that were surveyed for soil gas. The geophysical and soil gas investigation was not all-encompassing, and probably did not define the full extent of contamination in Area 7.

1.6.2 Contaminant Source Evaluation

Based on soil gas information, Areas 1 and 3 do not appear to be current, significant near-surface sources of VOC contamination.

Based on soil gas and soil boring information, Area 2 may be a current minor near-surface source of VOCs for the study area. Previous effects from this area may have been more significant.

Based on soil gas, soil borings, and groundwater data, Area 4 is a significant near-surface source of VOC contamination and is contributing to groundwater contamination in the study area. It is possible that non-aqueous phase liquids (NAPLs) are present at the water table and at depth in this area.

Based on the soil gas information, potential source Areas 5 and 6 do not appear to be near-surface sources of VOCs.

Based on groundwater, geophysical surveys, soil gas, and subsurface soil data collected during the Phase I and Phase II studies, source Area 7 is a significant near-surface source of VOC contamination and is contributing to groundwater contamination in the primary area of concern. It is possible that NAPLs are present at the water table and at a depth in this area.

Based on the groundwater analytical data and the hydrogeologic information, it appears that groundwater contamination originating from potential source Area 8 has a different contaminant fingerprint than groundwater contamination extending from Area 7 westward to Eleventh Street.

The groundwater analytical results downgradient from Areas 9 and 10 suggest a possible contaminant source near the southern part of the boundary between these areas. Due to limited access in portions of these areas, no specific near-surface sources of VOCs were identified.

Area 11 is characterized by high concentrations of ETX, especially at the water table, indicating a likely LNAPL (light non-aqueous phase liquid). An additional issue in this area is that due to the high concentrations of the ETX compounds, analytical detection limits were raised and it is unknown whether chlorinated VOCs are present at lower concentrations. The downgradient groundwater results do not indicate any major spikes that could be attributed to Area 11; however, the area could still be contributing chlorinated VOCs at lower concentrations.

Based on soil gas, soil boring, and local groundwater flow and analytical data, potential source Area 12 is a near-surface source of VOCs and a potential local groundwater contamination source; existing data are not sufficient to determine contribution to the primary area of concern.

Based on previous studies that indicated high concentrations of VOCs beneath the building at Acme Solvents, Phase II, soil gas and local groundwater flow and analytical data, potential source Area 13 is a near-surface source of VOCs and a local groundwater contamination source. Existing data are not sufficient to determine contribution to the primary area of concern.

Based on soil gas, soil borings, and groundwater data, Area 14 does not appear to be a current source of near-surface VOC contamination. Based on the previous existence of high contaminant concentrations in soils that were removed from the site in about 1989, it is likely that the site was at one time a source of contamination. However, in the areas investigated, there is currently little evidence of past problems, based on a lack of contaminant spikes in downgradient groundwater.

Based on groundwater data, the Erhardt-Leimer facility has a small groundwater contaminant plume (Area 15 plume) that has not reached the area of concern located downgradient.

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Section 2

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Section 2

Applicable or Relevant and Appropriate Requirements/Remedial Action Goals and Objectives

2.1 Introduction

This section provides (1) a summary of ARARs pertinent to the identification, screening, and selection of remedial alternatives for the Southeast Rockford Site and (2) preliminary remediation goals and objectives developed for the Site. A review of ARARs is provided in Section 2.2.4. A Human Health Risk Assessment (HRA) is provided in Section 6 of the RI Report. Remedial action goals developed in this section are based both on the ARAR analysis and HRA. It should be noted that source control and remediation will occur as part of a source-specific response action, separate from the actions described herein.

2.2 ARARs

The CERCLA Section 121, amended by Congress in the Superfund Amendments and Reauthorization Act of 1986 (SARA), in effect codifies the EPA approach to compliance with other laws. Section 121(d) and the National Contingency Plan (NCP) (40 CFR Part 300, March 8, 1990) require that CERCLA remedial actions comply with all federal ARARs. In addition, SARA 121(d) requires that for any material remaining on the Site, the level or standard of control that must be met for the hazardous substance, pollutant, or contaminant is at least that of any applicable or relevant and appropriate standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria, or limitation promulgated pursuant to a state environmental statute.

The statute requires compliance with ARARs at the completion of remedial action for material remaining on the Site. As a matter of policy and consistent with the March 8, 1990 NCP, ARARs must also be met during implementation of the selected remedy. Onsite remedies need only comply with the substantive portion of ARARs whereas offsite actions are subject to all applicable laws, both the substantive and administrative portions.

2.2.1 Definition of ARARs

Applicable Requirements are those cleanup standards of control and other substantive requirements, criteria, or limitations promulgated under federal, state or city environmental laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state and that are more stringent than federal requirements may be applicable.

Relevant and Appropriate Requirements are those federal, state and city requirements that, while not legally "applicable," are designed to apply to problems sufficiently similar to those encountered at CERCLA sites that their application is appropriate. While not technically applicable to a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstance at a Superfund site, relevant and appropriate requirements address problems sufficiently similar to those encountered at a Superfund site so that their use is well suited.

To-Be-Considered Material (TBCs) are federal and state non-promulgated requirements, such as guidance documents or criteria. Advisories or guidance documents do not have the status of potential ARARs. However, where there are no specific ARARs for a chemical or situation, or where such ARARs are not sufficient to be protective, guidance or advisories should be identified and used to ensure that a remedy is protective.

2.2.2 Classification of ARARs

The ARARs have been placed into three categories:

- Chemical-specific
- Action-specific
- Location-specific

Chemical-specific requirements are those health- or risk-based values that establish an acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Action-specific requirements are technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances. Finally, location-specific requirements are limitations on the use of specific locations, such as wetlands.

2.2.3 Consideration of ARARs

CERCLA Section 121 requires that remedial actions meet a level of standard of control that at least attains applicable or relevant and appropriate federal and state laws. A law is applicable if by its terms, it governs the situation at the Site. If the law is not applicable, it may be relevant and appropriate if circumstances at the Site are sufficiently similar to the problems or situations regulated by the law. Because each CERCLA site has unique characteristics, there are no required ARARs that can be specified in advance. ARARs must be identified for the unique particulars of the site (e.g., sensitive receptors, hazardous materials, and the suggested remedial alternatives). ARARs must be met for hazardous substances remaining on the Site at the completion of the remedial action and also during implementation of the remedial action.

2.2.4 Identification of ARARs

The following were considered during the ARAR identification process:

- Federal and State of Illinois requirements (applicable or relevant and appropriate)

Potential TBCs include:

- Federal and State of Illinois criteria, advisories, and guidance documents

The summary identification of ARARs presented in this section was based on current knowledge of the Site, available analytical data and review of ARARs established for sites with similar contamination. The ARARs from other sites were derived by reviewing EPA RODs. The review

of past EPA RODs from sites both within and outside of Region V focuses on the remedial alternatives selected and the final ARARs chosen. Appendix A lists the sites identified as having similar contamination to that of the Southeast Rockford Site (i.e., VOCs in groundwater), and a brief synopsis of the technologies applied to remediate the sites.

Table 2.2-1 provides a summary of potential ARARs at the Southeast Rockford Site. Based on the anticipated remedial actions at the Site (see Section 5), some of these potential ARARs may not apply.

Those that potentially do not apply are marked in the last column of Table 2.2-1. Based on Table 2.2-1 and Site conditions, the following are potential ARARs:

- Federal SDWA MCL (chemical-specific)
- Federal Resource Conservation and Recovery Act (RCRA) requirements for transport and regeneration of spent carbon (action and chemical specific)
- Federal National Pollution Discharge Elimination System (NPDES) permit requirements for discharge to Rock River (action-specific)
- Illinois Groundwater Protection Act (IGWPA) (action- and chemical-specific)
- Illinois permit and control requirements for air emissions from air strippers (action- and chemical-specific)
- Illinois permit requirements for underground injection of water (action-specific)
- City permit requirements for discharge to Publicly-Owned Treatment Works (POTW) (action- and chemical-specific)

These ARARs have a direct effect upon the remedial actions selected. NPDES, Illinois Underground Injection Control (UIC), and Illinois Air Emission Source Construction permits can be obtained but may take considerable time. The IEPA Division of Air Pollution Control will require off-gas containment of any air stripper that exceeds a total volatile emission rate of 8 lb/hour. Any groundwater that is remediated will require treatment to MCLs or IGWPA levels, whichever is more stringent; or to NPDES discharge levels depending on the discharge option selected. MCLs and IGWPA Class I Groundwater Standards for all VOCs that exceed MCLs in groundwater levels are provided in Table 2.2-2. Table 3.4-4 summarizes potential NPDES discharge levels.

The IGWPA was set up in 1987 to respond to the need to manage groundwater quality by prevention oriented processes. It establishes comprehensive water quality standards for groundwater, provides for the use of water well protection zones, and allows for the establishment of groundwater management zones (GMZs) within any class of groundwater. A GMZ can be established where groundwater is being managed to mitigate against effects caused by the release of contaminants from a site. GMZ provisions recognize the practical limitations commonly associated with remediating groundwater contamination and links technological

**Table 2.2-1
Summary of Potential ARARs**

Act/ Regulation	Federal, State, or City	Type of ARAR	Parameter/ Program	Description	Probably Will Not Apply
CAA	F	Chemical	VC	VC emissions limited to <10 ppm	X
SDWA	F	Chemical	MCLs	MCLs for volatile organics	
RCRA	F	Location	100 year floodplain	Controls type of construction in 100 year floodplain	X
RCRA	F	Chemical /Action	Spent Carbon	Manifest/Transport/Regenerate Spent Carbon	
CWA	F	Action	NPDES	Discharge permit required (to Rock River)	
CWA/RCRA	F	Action	POTW	Regulates discharge to POTW	X
SDWA	F	Action	UIC	Regulates injection of groundwater	X
Discharge to POTW	F	Chemical /Action	POTW	Requires permit and controls total organics	
Illinois Groundwater Protection Act	S	Chemical /Action	Groundwater	Establishes groundwater management zones	
Air Pollution Emission Control Regulations	S	Action	Air emission	Permit required for all emissions. Requires control of off-gas if emission > 8 lbs/hr	
UIC Regulations	S	Action	UIC	Permit and controls required	
Discharge to Storm Sewer	F	Action	NPDES	Requires discharge permit	

F = Federal
S = State
C = City

Table 2.2-2
ARARs Summary Table — Groundwater
(µg/L)

Contaminants	MCL	IGWPA
1,1-Dichloroethane (1,1-DCA)	—	—
1,1-Dichloroethene (1,1-DCE)	7	7
1,1,1-Trichloroethane (1,1,1-TCA)	200	200
<i>cis</i> -1,2-Dichloroethene (<i>cis</i> -1,2-DCE)	70	70
Tetrachloroethene (PCE)	5	5
Trichloroethene (TCE)	5	5
<i>trans</i> -1,2-dichloroethene (<i>trans</i> -1,2,-DCE)	100	100
Vinyl chloride	2	2
Dichloromethane	5	5
1,2-Dichloroethane (1,2-DCA)	5	5
1,2-Dichloropropane	5	5
1,1,2-Trichloroethane (1,1,2-TCA)	5	5
Benzene	5	5
Toluene	1,000	1,000
Ethylbenzene	700	700
Xylene	10,000	10,000

"—" = No Value

Contaminants listed are those that were detected at levels greater than MCLs or IGWPA Class I Groundwater Standards within the study area.

approaches and practices with standards regulation. The area of a GMZ can be established with reference to a given point of compliance and an appropriate period of time to achieve compliance. The groundwater within the study area is considered Class I groundwater under the definitions provided by the Act.

POTWs are designed to treat domestic wastewater or sewage. In general, POTWs are not designed to treat heavy metals, solvents, organics, and other types of toxic pollutants. POTWs are certainly not for "offsite" treatment or "disposal" of contaminated groundwater. The treatment of toxic pollutants, if it occurs at all in a POTW treatment plant, is incidental to the design of most POTWs and involves to a large extent taking advantage of the treatment system's ability to dilute non-domestic or industrial discharges, as well as adsorption of toxic pollutants to particles that settle out into the sludge. Thus, a significant portion of the heavy metals and organic compounds that are introduced into the headworks of a POTW treatment plant end up in the POTW's sewage sludge. Therefore, careful attention must be paid to the following ARARs for the discharge of pre-treated groundwater to a POTW for tertiary treatment or disposal.

1. 40 CFR Part 122.42(b), NPDES Permit Regulations - Requires notification of issuing authority of re-evaluation of POTW pretreatment standards. (It must be noted that in the event that the POTW does not have a local limitation for a particular pollutant found in the groundwater from this Superfund site, it must evaluate its local limitations, and develop such a limitation as necessary to protect the POTW from interference, pass-through, or inhibition from that discharge.)
2. 40 CFR Part 403.5, NPDES National Pretreatment Standards - Discharge to a POTW must not interfere, pass through untreated into the receiving waters, or contaminate the sewage sludge.
3. 40 CFR Part 403.8(f), NPDES Pretreatment Program Requirements for POTWs.

2.2.5 Risk Considerations for ARARS

This section presents an evaluation of the risks associated with exposure to the mixture of detected chemicals at ARAR concentrations, or in the absence of an ARAR, at a risk-based concentration. This exercise was conducted for both the entire study area and the residential study area. The risk-based concentrations were the 1E-06 cancer risk level or hazard index of 1.0.

CERCLA guidance (EPA, 1991) states that an acceptable range of excess lifetime cancer risk is 1E-06 to 1E-04. The sum of the risks associated with all chemicals and all exposure pathways is to be compared to this risk range. The upper boundary of the risk range is not a discrete line at 1E-04, although EPA generally uses 1E-04 in making risk management decisions. A specific risk estimate around 1E-04 may be considered acceptable if justified based on site-specific conditions. In certain cases, EPA may consider risk estimates slightly greater than 1E-04 to be protective. For noncarcinogenic risks, EPA guidance does not specify a range, but it is generally appropriate to assume a hazard index of 1.

USEPA guidance also states that compliance with a chemical specific ARAR generally will be considered protective even if it is outside the risk range (unless there are extenuating circumstances such as exposure to multiple contaminants or pathways of concern). Because

there are multiple contaminants at the site, an evaluation has been conducted in order to determine whether clean-up to ARARs and risk-based concentrations for individual chemicals would result in residual risk outside of the acceptable risk range. The support documentation for this evaluation is presented in Appendix D.

Risk were estimated for the following two hypothetical residences:

- Hypothetical residence #1 includes all chemicals detected within the entire study area, in at least 5 percent of the samples, regardless of concentration.
- Hypothetical residence #2 includes all chemicals detected within the residential study area regardless of concentration.

If available, the MCL/IGWPA Class I Standards were used as the exposure point concentration. In the absence of an MCL, the lower of the maximum detected concentration or risk-based concentration was used as the exposure point concentrations.

Total cancer risks for both hypothetical residences only slightly exceeded the EPA acceptable risk range of $1.0\text{E-}06$ to $1.0\text{E-}04$. Cancer risks for hypothetical residence #1 were estimates to be $2.2\text{E-}04$; cancer risks for hypothetical residence #2 were estimated to be $1.3\text{E-}04$. The major contributor to cancer risk for both was 1,1-dichloroethene.

Total hazard index for both hypothetical residences exceeded the hazard index of 1. The hazard index for residence #1 was estimated at 10; the hazard index for residence #2 was estimated at 1.8. The major contributors to hazard index were xylene and toluene for hypothetical residences #1 and 1,1,1-trichloroethane and 1,1-dichloroethane for hypothetical residence #2. Several semi-volatiles also contributed significantly to the total hazard index for residence #1. Table 2-1 presents a summary of hazard index and risks associated with exposure to MCLS and maximum or risk-based concentrations.

2.2.6 Development of Alternative Cleanup Levels

Estimated cancer risks and total hazard index exceeded that acceptable cancer and noncancer limits for both hypothetical residences when residual concentrations were assumed equal to MCLs and maximum or risk-based concentrations (in the absence of MCLs). For this reason, alternative cleanup levels were developed. Exposures to these concentrations would not exceed cancer and noncancer limits. Tables 2-2 and 2-3 present the total hazard index and cancer risk by chemical for hypothetical residences #1 and #2, respectively.

The calculation of alternative cleanup levels was in iterative process of reducing concentrations until risks and total hazard index were within acceptable limits. Chemicals with the highest MCLs, maximum or risk-based concentrations which contributed most significantly to cancer risk or hazard index were targeted first. Tables 2-4 and 2-5 present alternative cleanup levels associated with cancer risks that do not exceed $1\text{E-}04$ and total hazard indices that do not exceed 1.0. The adjusted concentration are presented in bold and italics. Support documentation for this exercise is presented in Appendix D.

TABLE 2-1

RISK SUMMARY TABLE - RISKS AT MCL AND MAXIMUM OR RISK-BASED CONCENTRATIONS

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

HYPOTHETICAL RESIDENCE	<u>HAZARD INDEX</u>					<u>CANCER RISK</u>				
	Ingestion	Dermal	Inhalation Household	Inhalation Shower	Total	Ingestion	Dermal	Inhalation Household	Inhalation Shower	Total
1	1.8	0.7	4.9	2.7	10	1.1E-4	1.0E-5	6.7E-5	2.9E-5	2.2E-4
2	0.7	0.4	0.5	0.3	1.8	5.9E-5	7.5E-6	5.0E-5	2.7E-5	1.4E-4

TABLE 2-2 - TOTAL RISKS AND HAZARD INDEX AT MCLS AND MAXIMUM OR RISK-BASED CONCENTRATIONS
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION
HYPOTHETICAL RESIDENCE #1

Chemical	Concentration	Total Hazard Index	Total Cancer Risk
Vinyl Chloride	0.002		7.2E-05
Chloroethane	0.500	5.3E-02	
Methylene Chloride	0.0050	2.9E-03	7.9E-07
1,1-Dichloroethene	0.0070	2.4E-02	1.1E-04
1,1-Dichloroethane	0.80	7.8E-01	
Cis-1,2-Dichloroethene	0.070	2.1E-01	
Trans-1,2-Dichloroethene	0.100	1.5E-01	
Chloroform	0.00015	4.4E-04	5.3E-07
1,2-Dichloroethane	0.0050	1.7E-01	2.5E-05
1,1,1-Trichloroethane	0.200	4.4E-01	
1,2-Dichloropropane	0.005	4.3E-01	4.3E-06
Trichloroethylene	0.005	2.6E-02	2.0E-06
Benzene	0.005	2.9E-01	
Tetrachloroethene	0.005	2.1E-02	8.1E-06
Toluene	1	1.0E+00	5.1E-06
Ethylbenzene	0.7	5.4E-01	
Xylene	10	5.2E+00	
<i>Semivolatile Organics</i>			
1,2-Dichlorobenzene	0.026	6.5E-02	
2-Methylphenol	0.100	5.7E-02	
4-Methylphenol	0.088	5.0E-01	
2,4-Dimethylphenol	0.054	7.7E-02	
Napthalene	0.043	4.7E-02	
2-Methylnapthalene	0.005	4.0E-03	
Di-n-butylphthalate	0.001	5.0E-04	
bis(2-Ethylhexyl)Phthalate	0.006	1.0E-02	1.2E-06

TOTAL HAZARD INDEX	1.0E+01	TOTAL CANCER RISK	2.3E-04
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TABLE 2-3 - TOTAL RISKS AND HAZARD INDEX AT MCLS AND MAXIMUM OR RISK-BASED CONCENTRATIONS
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION
HYPOTHETICAL RESIDENCE #2

Chemical	Concentration	Total Hazard Index	Total Cancer Risk
Methylene Chloride	0.005	2.9E-03	7.9E-07
1,1-Dichloroethene	0.007	2.3E-02	1.1E-04
1,1-Dichloroethane	0.8	7.8E-01	
Cis-1,2-Dichloroethene	0.07	2.1E-01	
Trans-1,2-Dichloroethene	0.10	1.5E-01	
Chloroform	0.00015	4.4E-04	5.3E-07
1,2-Dichloroethane	0.005	1.7E-01	2.5E-05
1,1,1-Trichloroethane	0.2	4.4E-01	
Trichloroethene	0.005	1.7E-02	2.0E-06
Tetrachloroethylene	0.005	2.1E-02	5.1E-06

TOTAL
HAZARD
INDEX

TOTAL
CANCER
RISK

1.8E+00
1.4E-04

TABLE 2-4 - TOTAL RISK AND HAZARD INDEX AT ALTERNATIVE CLEANUP LEVELS
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION
HYPOTHETICAL RESIDENCE #1

Chemical	Concentration	Total Hazard Index	Total Cancer Risk
Vinyl Chloride	<i>0.00100</i>		3.6E-05
Chloroethane	0.50000	5.3E-02	
Methylene Chloride	0.00500	2.9E-03	7.9E-07
1,1-Dichloroethene	<i>0.00100</i>	3.4E-03	1.5E-05
1,1-Dichloroethane	<i>0.10000</i>	9.8E-02	
Cis-1,2-Dichloroethene	<i>0.01000</i>	2.9E-02	
Trans-1,2-Dichloroethene	<i>0.01000</i>	1.5E-02	
Chloroform	0.00015	4.4E-04	5.3E-07
1,2-Dichloroethane	0.00500	1.7E-01	2.5E-05
1,1,1-Trichloroethane	<i>0.01000</i>	2.2E-02	
Trichloroethylene	0.00500	2.6E-02	2.0E-06
Benzene	0.00500	2.9E-01	8.1E-06
Tetrachloroethene	0.00500	2.1E-02	5.1E-06
Toluene	<i>0.01000</i>	1.0E-02	
Ethylbenzene	<i>0.10000</i>	7.7E-02	
Xylene	<i>0.01000</i>	5.2E-03	
<i>Semivolatile Organics</i>			
1,2-Dichlorobenzene	<i>0.010</i>	2.5E-02	
2-Methylphenol	<i>0.010</i>	5.7E-03	
4-Methylphenol	<i>0.010</i>	5.7E-02	
2,4-Dimethylphenol	0.054	7.7E-02	
Napthalene	0.043	4.7E-02	
2-Methylnapthalene	0.005	4.0E-03	
Di-n-butylphthalate	0.001	5.0E-04	
bis(2-Ethylhexyl)Phthalate	0.006	1.0E-02	1.2E-06

Modified cleanup levels in italics and bold

TOTAL HAZARD INDEX	TOTAL 1.0E+00 CANCER RISK	9.4E-05
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TABLE 2-5 - TOTAL RISKS AND HAZARD INDEX AT ALTERNATIVE CLEANUP LEVELS
 SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION
 HYPOTHETICAL RESIDENCE #2

Chemical	Concentration	Total Hazard Index	Total Cancer Risk
Methylene Chloride	0.005	2.9E-03	7.9E-07
1,1-Dichloroethene	0.004	1.4E-02	6.1E-05
1,1-Dichloroethane	0.7	6.9E-01	
Cis-1,2-Dichloroethene	0.01	2.9E-02	
Trans-1,2-Dichloroethene	0.01	1.5E-02	
Chloroform	0.00015	4.4E-04	5.3E-07
1,2-Dichloroethane	0.005	1.7E-01	2.5E-05
1,1,1-Trichloroethane	0.01	2.2E-02	
Trichloroethene	0.005	1.7E-02	2.0E-06
Tetrachloroethylene	0.005	2.1E-02	5.1E-06

Modified cleanup levels in italics and bold

TOTAL HAZARD INDEX	9.8E-01	TOTAL CANCER RISK	9.5E-05
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2.3 Remedial Action Objectives

RAOs are the formal statement of the overall objectives and goals for the Site. RAOs are site-specific, quantitative goals that define the extent of cleanup required to achieve the response objectives. They include the preliminary cleanup levels, the area of attainment, and the restoration time frame.

Establishment of RAOs is the first step of the FS process. As stated previously in Section 2.1, individual sources of contamination will be subjected to source-specific response actions. As such, contaminated groundwater is the only medium of concern for the Site-wide Remedial Action, and the RAOs will address only groundwater. Therefore, the RAOs described in this section can be considered as interim RAOs, since source control is not provided. The RAOs for the Site are as follows:

- Prevent ingestion and/or inhalation exposure from use of contaminated groundwater.
- Protect uncontaminated groundwater and surface water for current and future use.
- Control future releases of contaminants to ensure protection of human health and the environment (SARA Section 121 [d]) — This RAO will be addressed by source-specific response actions.
- Permanently and significantly reduce mobility, toxicity, or volume of the contamination with treatment (SARA Section 121 [d]).
- Protect environmental receptors.

Numerical values to accomplish these objectives are presented in Table 2.2-2.



Section 3

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Three

Section 3

Identification, Screening, and Evaluation of Technologies and Process Options

This section presents the identification and screening of corrective action technology types and process options applicable to the Southeast Rockford Site. Potential technologies for long-term extraction, treatment, containment, and disposal were identified. As part of the identification process, a summary of RODs on sites similar to the Southeast Rockford Site is presented in Section 3. The identified technologies and process options were evaluated on the basis of technical feasibility. Retained technologies and process options were further evaluated on the basis of effectiveness, implementability, and cost.

3.1 General Response Actions

General response actions for groundwater remediation include several extraction, treatment, containment, and disposal options. Technologies within these categories have been considered for constituents in the groundwater at the Site. Response actions and remedial technologies presented in this section are based on site conditions as presented in the RI Report. In summary, there are multiple primary sources for each of the COCs; further, the plumes associated with these sources are not necessarily coincident.

General response actions are defined as actions that, singly or in combination, will meet the remedial action objectives defined in Section 2 or will provide a baseline for comparison with other actions. Restoration of groundwater to MCLs within a reasonable time frame, and prevention of exposure to contaminated groundwater are the goals of the remedial action.

The general response actions for the Southeast Rockford Site include both passive and active measures to mitigate existing and future groundwater contamination. Passive measures include those that involve no direct containment or treatment of groundwater, such as continued monitoring of contaminant plume migration or restrictions on groundwater use. Active measures include the installation of systems that will contain and/or treat contaminated groundwater. For the groundwater at the Southeast Rockford Site, the following general response actions have been identified:

- No Action
- Institutional Controls
- Natural Attenuation
- Containment
- Removal/Groundwater Extraction
- Direct Treatment
- Offsite Treatment
- *In situ* Treatment
- Discharge of Treated Water

The general response actions listed above provide a basis upon which to assemble and then screen remedial technologies. Process options are selected as representative of the remedial technology. Although specific processes are selected for further development and evaluation,

these process options are intended to represent the broader range of process options within a general technology group. Once identified, acceptable technologies are assembled into remedial action alternatives that satisfy the remedial action objectives defined in Section 2. Screening of medium-specific technologies occurs at this stage of the FS, evaluation of the alternatives occurs during subsequent stages.

3.2 Summary of RODs and Other Applicable Treatment Technology Data Sources

A major source of information for both ARARs and treatment technologies can be found in the Federal RODs for CERCLA sites that are similar to the Southeast Rockford Site. ARARs have been discussed previously in Section 2 of this report.

A summary of RODs is presented as Appendix A. RODs were considered to be relevant to the Site if groundwater was contaminated by 1,1,1-TCA, PCE, TCE, 1,1-DCE, 1,2-DCE, or 1,1-DCA. For the RODs cited, a variety of treatments are listed that range from no action and natural attenuation to complete physical/chemical treatment of groundwater. A total of 130 RODs were relevant: 6 in FY 86-89, 44 in FY 90, 42 in FY 91, 31 in FY 92, and 7 in FY 93. Groundwater technologies (and the number of occurrences in the RODs) are provided in Table 3.2-1. Because of multiple treatment processes, the total occurrences above will not sum to 130.

3.3 Preliminary Screening of Technologies and Process Options

Technologies were assembled that potentially would satisfy the remedial objectives described above. The technologies were identified from a review of recent and past RODs, and included elements of institutional controls, containment, extraction/removal, treatment, and disposal.

Groundwater technologies identified for institutional controls included groundwater monitoring to continue to measure the nature and extent of the contamination, use restrictions to prevent the use of groundwater wells for drinking or bathing purposes and thus prevent the ingestion or inhalation of the VOCs, and public education to inform Southeast Rockford residents of the appropriate (i.e., nonpotable) use of groundwater. Containment technologies included both vertical and horizontal barriers. Collection technologies included extraction systems and subsurface drains. Treatment technologies included *in situ* treatment, direct biological or physical/chemical treatment, and offsite treatment at either a POTW or hazardous waste treatment facility. Discharge technologies included onsite discharge through injection systems and offsite discharge through the sanitary sewers and the POTW, surface water, storm sewers, and reuse for either potable or nonpotable uses.

The preliminarily identified technology types and process options applicable to groundwater remediation at the Southeast Rockford Site are presented in Table 3.3-1. As shown, several entire technology types and process options have been eliminated from further consideration solely on

the basis of technical feasibility. Technical feasibility is a determination of whether a technology can be implemented at the site (EPA 1988). An example of a technology that is not implementable is a biological process for the removal of nonbiodegradable contaminants such as asbestos. The retained technologies are further evaluated for groundwater in Section 3.4.

**Table 3.2-1
Summary of Groundwater RODs**

Alternative	Number of Occurrences				
	FY 86-89	FY 90	FY 91	FY 92	FY 93
No action, including "natural attenuation"	2	2	4	5	0
Institutional controls					
Monitoring	3	32	30	20	1
Deed and/or groundwater use restrictions	2	15	22	10	1
Containment					
Hydraulic controls	5	44	6	8	1
Treatment					
Air stripping with off-gas treatment	0	10	15	0	1
Air stripping without off-gas treatment, or not specified	1	19	16	12	1
Granular activated carbon adsorption	1	24	19	5	0
Chemical precipitation	0	10	9	2	0
Filtration	0	11	6	1	0
Chemical oxidation	0	8	4	4	0
Biological	1	4	2	0	0
Ion exchange	0	2	0	0	0
Thermal	1	1	2	0	0
Disposal					
Offsite; e.g., POTW	1	11	6	3	0
Onsite surface water	2	20	25	3	0
Onsite reinjection	0	13	9	3	0

Table 3.3-1
Initial Screening of Groundwater Technologies and Process Options
Southeast Rockford Groundwater Contamination Study, Rockford, Illinois

Groundwater General Response Actions	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not applicable	No action	Required for consideration
Institutional actions	Use restrictions	Use restrictions	Use restrictions of groundwater	Potentially applicable - only method to protect public during remediation period
		Public education	Educate residents on appropriate use of water (non-potable use)	Potentially applicable
	Alternate water supply	City water supply	Extension of existing municipal well system in the area of influence	Potentially applicable
	Monitoring	Groundwater monitoring	Ongoing monitoring of wells	Potentially applicable
Containment	Vertical barriers	Slurry wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry to form an impermeable barrier	Not feasible due to depth of contaminated aquifers
		Grout curtain	Pressure injection of grout in a regular pattern of drilled holes to form an impermeable barrier	Not feasible due to depth of contaminated aquifers
		Sheet piling	Lengths of steel sheets are connected together and driven into the ground to form an impermeable layer	Not feasible due to depth of contaminated aquifers
		Hydraulic controls	Series of wells to control groundwater flow	Potentially applicable
	Horizontal barrier	Capping	An impermeable material is placed over an area to minimize infiltration of precipitation or surface water	Not applicable due to low effectiveness in residential/commercial area, especially for a large area of concern
		Vertical extraction wells	Series of wells to extract contaminated groundwater	Potentially applicable
Collection Treatment (see next page) Discharge (see next page)	Extraction	Extraction/Injection wells	Injection wells inject uncontaminated (i.e., recycled) water to increase flow to extraction wells	Potentially applicable
		Horizontal extraction wells	Lateral buried conduits used to extract contaminated groundwater	Potentially applicable
		Subsurface drains	Perforated pipe in trenches backfilled with porous media to collect contaminated water	Not feasible due to depth of contaminated aquifer and land use
	In situ treatment	Aerobic bioremediation	System of injection and extraction wells to introduce oxygen, bacteria, and nutrients to degrade contamination	Potentially applicable
		Anaerobic bioremediation	System of injection and extraction wells to introduce bacteria and nutrients to degrade contamination	Potentially applicable
		Air sparging	System of wells to inject air into groundwater to remove volatiles by air stripping	Potentially applicable
		Steam sparging	Injection of steam into groundwater to remove volatiles by steam stripping	Innovative technology, not fully demonstrated - not retained
		Reactive barrier wall	Downgradient trenches backfilled with treatment media to remove contaminants from water	Innovative technology, not fully demonstrated - not retained
		Chemical reaction	System of injection wells to inject oxidizer such as hydrogen peroxide to degrade contaminants	Not feasible because of potential for volatilizing contaminants and contaminating clean soil
(see next page)				
<div></div> Process option eliminated from further consideration				

 Process option eliminated from further consideration

Table 3.3-1 (Cont.)

Groundwater General Response Actions	Remedial Technology	Process Option	Description	Screening Comments	
Treatment <i>(see previous page)</i>	Offsite treatment	Deep well injection	Extracted groundwater transported to a licensed well for disposal	Potentially applicable	
Discharge		Hazardous wastewater treatment facility	Extracted groundwater transported to a TSD facility for treatment	Potentially applicable	
		POTW	Extracted groundwater transported to a POTW facility for treatment	Potentially applicable	
	Biological treatment	Aerobic	Degradation of organics using microorganisms in an aerobic environment	Potentially applicable	
		Anaerobic	Degradation of organics using microorganisms in an aerobic environment	Potentially applicable	
		Anaerobic/aerobic	Degradation of organics using microorganisms using a sequence of both anaerobic and aerobic environments	Potentially applicable	
	Physical/Chemical treatment	Chemical precipitation	Addition of chemicals for ion precipitation	Not effective for removal of organics	
		Air stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air	Potentially applicable	
		Tray aeration	Mixing large volumes of air with water by induced aeration to promote transfer of VOCs to air	Potentially applicable	
		Carbon adsorption	Adsorption of contaminants on to activated carbon by passing water through carbon column	Potentially applicable	
		Reverse osmosis	Use of high pressure to force water through a membrane leaving contaminants behind	Not fully demonstrated for organic contaminant removal	
		Ozone oxidation	Oxidation of organic compounds by introducing ozone	Requires pretreatment and reject stream requires further treatment - not retained	
		Ultraviolet/chemical oxidation	Oxidation of organic compounds by UV/chemical oxidation	Potentially applicable	
		Ion exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water	Not demonstrated at full scale - not retained	
		Dechlorination	Extraction of halogenated ions	Ineffective on low concentrations - not retained	
		Thermal treatment	Combustion and removal of organic compounds from groundwater	Potentially applicable	
		Pervaporation	Polymeric membrane-based ultrafiltration process for the removal of organics from water	Innovative technology, not fully demonstrated - not retained	
		Onsite discharge	Injection wells	Injection wells inject extracted and treated water into aquifer	Potentially applicable
			Infiltration galleries	Extracted and treated water discharged through buried conduits	Potentially applicable
Infiltration basins			Extracted and treated water discharged to onsite infiltration basins	Not feasible because of land restrictions	
Spray irrigation			Extracted and treated water discharged through a spray irrigation system	Not feasible because of land restrictions	
Offsite discharge	POTW	Extraction and treated water discharged to local POTW	Potentially applicable		
	Pipeline to surface water	Treated water discharged to Rock River	Potentially applicable		
	Reuse	Reuse/recycling of treated water for potable or non-potable use	Potentially applicable		

Process option eliminated from further consideration

Process option eliminated from further consideration

Technologies and process options within technology types that were screened from further evaluation on the basis of technical feasibility are indicated in Table 3.3-1 by shading. Screened technologies included horizontal groundwater containment barriers, because of the difficulties in implementation in a residential/commercial area especially one the size of southeast Rockford Area of Concern; and subsurface drains and vertical barriers, because of the depth of the groundwater aquifers (>100 feet) and difficulties in implementation in a residential/commercial area.

Groundwater process options that were screened include:

- Reactive barrier walls, which were considered technically infeasible due to the depth of the aquifer.
- *In situ* chemical reaction, because of the potential to volatilize the contaminants and contaminate otherwise clean soils; in addition, the technology has not been demonstrated on a full-scale.
- Steam sparging, which is not necessary for the volatile COCs and has not been demonstrated on a full-scale.
- Chemical precipitation, because VOCs do not participate in precipitation reactions
- Reverse osmosis, which is a separation process that reduces the concentration of groundwater constituents by concentrating the constituents into a smaller volume of a waste stream, because the technology has not been fully demonstrated for the removal of VOCs at the scale envisioned.
- Ion exchange, which was considered infeasible because it had not been fully demonstrated for VOCs.
- Pervaporation, because the high flow rates anticipated for remediation are not compatible with a membrane ultra filtration technique.
- Dechlorination, because it not a feasible reaction at lower concentrations.
- Infiltration basins and spray irrigation, because of the infeasibility of construction and operation in a residential/commercial area.

3.4 Evaluation of Retained Technologies and Process Options for Groundwater

The following sections present a description and an evaluation based on effectiveness, implementability, and cost for each of the retained remedial technologies and associated process options under the groundwater containment, collection, treatment, and discharge response actions.

The effectiveness analysis is based on the relative merits of a process option when compared to other processes within the same technology type. The criteria used in the effectiveness evaluation are:

- The ability of the process to address the estimated volume of contaminated media and to attain remediation goals;
- Potential environmental and health impacts during implementation of the process; and
- Reliability of the process with respect to Site contaminants and conditions.

The implementability evaluation includes the technical and administrative feasibility of the process option. Technologies that are clearly ineffective or incompatible with the Site were previously eliminated in Section 3.3. This analysis focuses on institutional implementability, including:

- Ability to obtain necessary regulatory permission (e.g., permitting); and
- Availability of appropriate process services (e.g., vendors, technicians).

At this stage of the evaluation, cost plays a limited role in the screening of process options. Each process is evaluated based on its costs being high, medium, or low relative to other processes in the same technology type. Cost analysis of process options will have less significant consequences than either effectiveness or implementability (EPA 1988).

Process options for groundwater, arranged according to technologies and response actions, are listed in Table 3.4-1. Also summarized in this table are the relative comparisons and screening of process options within each technology type. The evaluations of each of the process options are summarized in the following sections.

3.4.1 No Action

The no action alternative was retained to be combined with the groundwater monitoring process option. In addition, institutional controls such as deed restrictions and connection to the municipal water supply are also considered for each alternative evaluated in Section 3.

No action consists of leaving the Site as it is without conducting any further remedial action. Although this option is technically feasible and inexpensive, it is not effective in removing the contaminants from the Site. The evaluation of no action is required by the SARA.

3.4.2 Institutional Controls

Institutional controls function to prevent or reduce public contact with contaminated groundwater and have little or no effect on the presence of contamination. Institutional controls ranging from Site access restrictions, to deed restrictions, to the prohibition of the use of groundwater have been employed in a majority of the RODs described in Section 3.2.

Table 3.4-1
Evaluation of Groundwater Technologies and Process Options
Southeast Rockford Site, Rockford, Illinois

Groundwater General Response Actions	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Screening Status
No Action	None	Not applicable	Does not achieve remedial action objectives	Not acceptable to local/public government	None	Retained
Institutional actions	Use restrictions Monitoring	Use restrictions	Moderate	Moderate	Moderate	Retained
		Public education	Low	High	Low	Retained
		Groundwater monitoring	Low	High	Moderate	Retained
Containment	Vertical barriers	Slurry wall	Moderate	Low	High	Screened
		Grout curtain	Low	Low	Moderate	Screened
		Sheet piling	Low	Low	High	Screened
		Hydraulic controls	High	High	Moderate	Retained
Collection	Extraction	Vertical extraction wells	Moderate	High	Low	Retained
		Horizontal extraction wells	High	Low	High	Screened
		Extraction/injection wells	Moderate	Moderate	Moderate	Retained-discussed separately
Treatment (see next page) Discharge (see next page)	In situ treatment	Aerobic bioremediation	Moderate	Moderate	Low	Retained
		Anaerobic bioremediation	Moderate	Moderate	Low	Retained
		Air sparging	High	High	Moderate	Retained
	offsite treatment	Deep well injection	High	Moderate	High	Screened
		Hazardous wastewater treatment facility	High	Low	High	Screened
		POTW	Moderate	Low	Low	Screened
(see next page)						

Table 3.4-1 (Cont.)

Groundwater General Response Actions	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Screening Status
<div>Collection (see previous page)</div> <div>Treatment (see previous page)</div> <div>Discharge</div>	Biological treatment	Aerobic	Moderate	High	Low	Screened
		Anaerobic/aerobic	High	Moderate	Moderate	Retained
	Physical/Chemical treatment	Air stripping	High	High	Low	Retained
		Carbon adsorption	Moderate	High	High	Retained
		Ultraviolet/chemical oxidation	High	Moderate	High	Screened
		Thermal treatment	High	Low	High	Screened
	Onsite discharge	Injection wells	Moderate	High	Low	Screened
		Infiltration galleries	High	Moderate	Moderate	Retained
	Offsite discharge	POTW	Moderate	High	Moderate	Retained
		Surface water discharge	Moderate	Moderate	Low	Retained
		Reuse	Moderate	Low	High	Retained if large user identified

Process eliminated from further consideration

3.4.2.1 Use Restrictions/Community Relations

Use restrictions are an institutional control mechanism in which a governmental agency regulates the uses of groundwater.

The restriction on the potable use of groundwater would require a cooperative effort on the part of the City, the Winnebago County Health Department, the IDPH, and the IEPA. Restrictions on groundwater use is the only method by which public health can be protected during the period of remediation. The Winnebago County Health Department will not issue permits for potable water wells for residents where a water line is close enough that connection is feasible. This applies both to new homes and existing homes where a well has failed. The Winnebago County code also stipulates that existing wells must be abandoned once hook-up to the Utility System is complete. Additionally, the City of Rockford has an ordinance that prohibits well drilling within 400 feet of a public water main. There is currently no mechanism available to compel connection to the Utility System in order to protect human health. Institutional control of groundwater use will be a component of each remedial action, but they will not be fully effective without compliance from all residents within the potentially affected areas.

Although not technically an institutional control, public education and outreach programs can be used effectively to protect public health. This requires educating the public about the potential risks associated with using contaminated groundwater and discouraging the use of groundwater within the plume area for drinking or bathing. Water quality information can be disseminated through fact sheets, public meetings, and local news media announcements.

Public education has the capacity of achieving the remedial objective of preventing the ingestion of contamination and inhalation of volatile contaminants and will be associated with all alternatives evaluated. However, it would have no impact on contaminant migration and aquifer restoration.

3.4.2.2 Monitoring

Continued monitoring of groundwater quality is required to evaluate contaminant plume migration, natural attenuation of contamination, and effectiveness of the selected remedial action(s). Additional monitoring may also be required to complete the identification of primary sources of contamination.

3.4.3 Natural Attenuation

Natural attenuation relies on the groundwater's natural ability to lower contaminant concentrations through physical, chemical, and biological processes until cleanup levels are met.

The presence of *cis*-1,2-DCE, and to some extent, TCE, is a consequence of natural attenuation. Thus, the natural attenuation alternative includes biodegradation at suboptimal rates and without engineering controls. Therefore, under the natural attenuation alternative, some amount of contaminant removal would occur. However, without source control of contamination, the overall condition of the Site would not improve, within a reasonable time frame.

3.4.4 Containment

Through containment, the movement of groundwater through the contaminated area is controlled; thus, migration of the contaminants from the Site is minimized. Groundwater flow can be controlled by barrier systems and/or hydraulic controls.

3.4.4.1 Vertical Barriers

Four subsurface vertical containment process options were evaluated; slurry wall, grout curtain, sheet piling, and hydraulic controls. Because initial screening indicated that the first three options are not applicable to the Site due to the depth of groundwater and contamination, only hydraulic controls will be selected for the purpose of developing and evaluating Site-wide alternatives.

Hydraulic Controls

Hydraulic controls are a vertical barrier technology that influences contaminant migration by modifying the groundwater hydraulic gradient. This technology is most often employed as a component of the extraction remedial technology of the collection/treatment/discharges response action. Extraction technologies will likely result in short term mass reduction and when employed with source control, eventual long term aquifer restoration. Hydraulic controls are retained and are more fully described in Section 3.4.5.1.

3.4.5 Extraction

Removal of the groundwater contaminant plume can prevent contaminant migration off of the Site as well as reduce contaminant concentrations in the aquifer. The principal means of optimizing contaminated groundwater recovery is through the alteration of the groundwater gradient to enhance and/or control contaminant movement. This can be accomplished by placing an extraction system downgradient of the contaminated area or artificially influencing an existing gradient via groundwater extraction.

The reduction of contaminant concentrations over time is the primary indicator of the effectiveness of an extraction system for aquifer restoration. The ideal scenario would be a steady decrease in contaminant concentrations until the target level is attained. However, performance records suggest that although concentrations may drop initially, decline is often followed by a leveling of concentrations with little or no further decrease over time (EPA 1989; Doty and Travis 1991). For the Southeast Rockford Site, the rate of decrease of contaminant concentration would be dependent on timing and completeness of source control measures.

3.4.5.1 Extraction Wells

Extraction wells are commonly used as an extraction method to influence groundwater flow and recover contaminants. Extraction wells are used to contain the migration of a contaminant plume or reduce its size, and would be located downgradient of the original source areas. In general, extraction wells are versatile under a variety of site conditions and have design and operating flexibility. Although single or multiple wells can be used to sufficiently contain the spread of the dissolved constituent plume, multiple wells should be positioned in such a way that the cones of influence overlap. Due to their ease of installation, effectiveness at other groundwater remediation sites, and low capital and maintenance costs, extraction wells will be retained for further consideration.

3.4.5.2 Extraction/Injection Wells

This process option is a further variation on the groundwater extraction process. In this option, clean water is injected into the aquifer simultaneous with the extraction of contaminated water. The injection point can be either upgradient, downgradient, or immediately above the extraction point in a coupled well design. Reinjection can serve as an enhancement of extraction or as a method of disposal of treated groundwater. Upgradient injection can increase the hydraulic gradient and extraction rate; it can also be the vehicle by which oxygen and nutrients are introduced to stimulate biodegradation or the method of introduction of chemical oxidizers such as hydrogen peroxide. Downgradient injection may be the selected method of treated groundwater disposal in order to preserve the original groundwater hydrology. Extraction/injection wells are retained for further evaluation. However, the components of this option are discussed independently as a collection process (extraction wells, Section 3.4.4.1) and as an onsite disposal process (injection wells, Section 3.4.6.1).

3.4.5.3 Interceptor Trenches

Interceptor trenches are a process option of subsurface drain technology for the collection of contaminated groundwater. This technology is more suited to the collection of groundwater at shallow depths. In addition, the current high density land use within the Southeast Rockford Site renders the construction of trenches unfeasible. Therefore, this technology type was not retained for further analysis.

3.4.6 Treatment

Groundwater treatment may be conducted in conjunction with extraction or performed *in situ*. Treatment technologies that would employ extraction retained for evaluation include air stripping, carbon adsorption, aerobic or anaerobic/aerobic biological treatment, chemical treatment, shallow tray aeration and ultraviolet/chemical oxidation. *In situ* treatment technologies retained for evaluation include aerobic and anaerobic biodegradation and air sparging.

Many of the treatment technologies presented transfer the contaminant from the liquid to the gas phase. ARARs (i.e., Illinois Air Pollution Emission Control Regulations) require that the off-gas be treated prior to discharge to the atmosphere. Preliminary calculations indicate that it is not likely that the discharge of these contaminants to the atmosphere would exceed state and federal air quality regulations (permits required for discharges exceeding 8 lb/hr hour period). Off-gas treatment technologies are presented in Section 3.4.5.1.

3.4.6.1 Physical/Chemical Treatment

Air Stripping

Air stripping towers have been used effectively for removal of dissolved VOCs from groundwater and are considered the best available technology (BAT) for all the VOCs of concern at the Southeast Rockford Site (Clark and Adams 1991). A typical air stripping tower is shown in Figure 3.4-1. Contaminated water enters the stripping tower at the top and is evenly

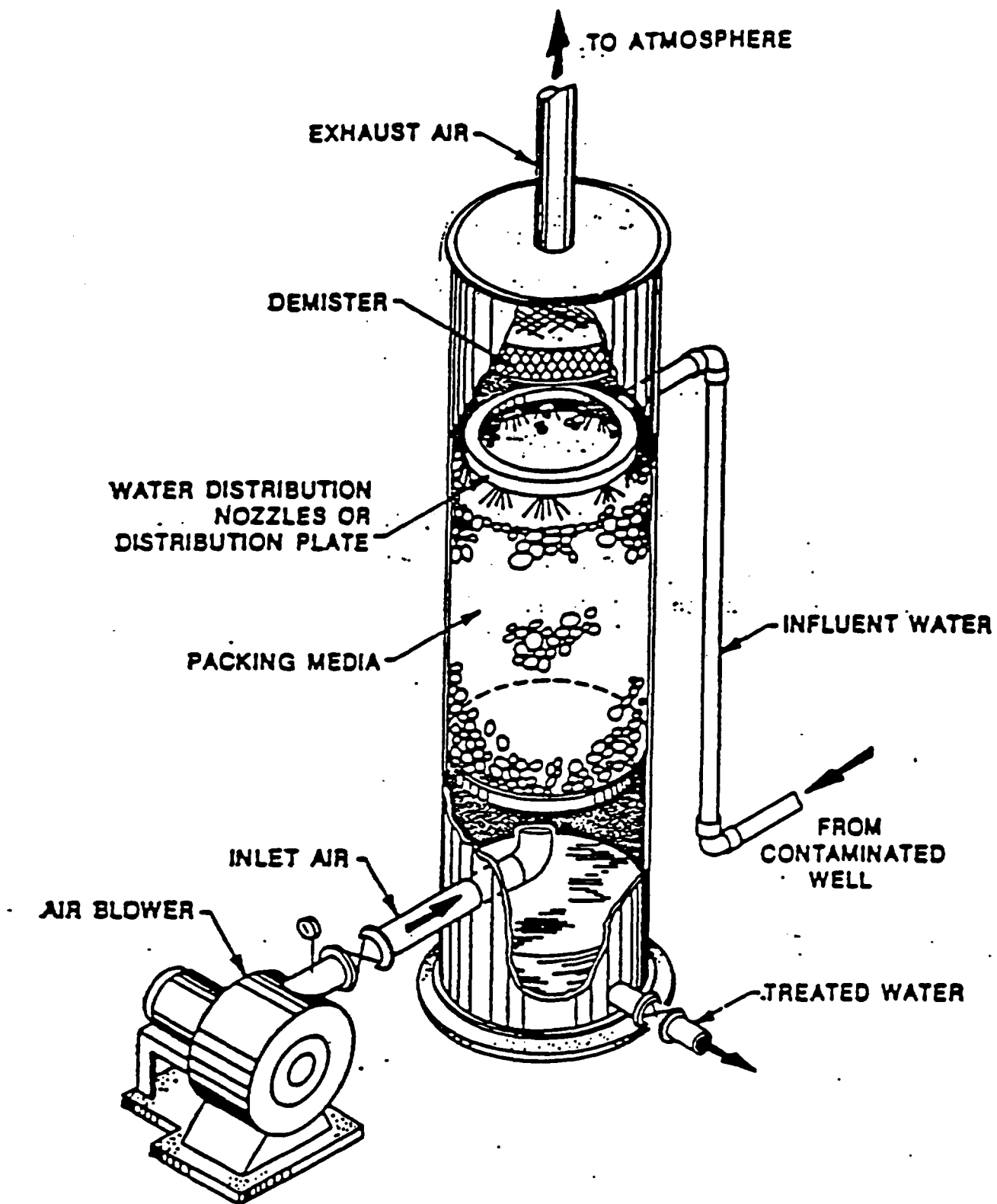


Figure 3.4-1 Typical Air Stripping Tower

distributed across the internal packing media through distributor nozzles. Clean air is introduced into the bottom of the tower below the packing using a forced air blower, and flows upward through the packing. As the falling contaminated water flows countercurrent to the rising air stream, VOCs are stripped from the water and enter the air stream. These organics are carried by the air stream out of the tower to the atmosphere or an off-gas treatment system. The internal packing media acts to increase the total surface area available for mass transfer of the organic contaminants from the liquid to the vapor stream. Treated water falls from the packing into the stripper basin and exits the tower as contaminant-free water.

The extent of compound removal by air stripping is governed by many factors, including contaminant concentrations in groundwater, air and water temperatures, the air-to-water ratio, and contaminant physical properties. One such physical property is the Henry's Law constant. Henry's Law states that the partial pressure of a compound (a measure of the concentration in the gas phase) at equilibrium is equal to a constant (Henry's Law constant) multiplied by the concentration of the compound in the liquid phase. Henry's Law constant is a partition coefficient that describes the relative tendency for the compound to partition between the gas and liquid phases at equilibrium conditions. The larger the Henry's Law constant, the greater the equilibrium concentration of the contaminant in the air phase. High Henry's Law constants indicate compounds that are more easily removed from solution than those having lower values. VOCs typically have dimensionless Henry's Law constants greater than 0.1 (Patterson 1985). As shown in Table 3.4-2, TCE, PCE, 1,1,1-TCA, 1,1-DCE, and *cis*-1,2-DCE should be easily removed by air stripping based on high Henry's Law constants.

Air stripping tower performance also depends largely on the presence or absence of various inorganic compounds and suspended solids in the groundwater. Groundwater with elevated hardness may result in calcium and magnesium salt deposits in the tower packing media. Elevated iron or manganese concentrations, when oxidized in the air stripper, will result in metal hydroxide precipitation, which can severely foul the packing media and reduce its effectiveness to remove VOCs. In addition, elevated total suspended solids (TSS) concentrations in the groundwater can also result in solids deposition on the tower packing and reduce liquid-to-air mass transfer.

Pretreatment equipment, if required to control scaling, could consist of clarification/equalization basins or multi-media filters to remove TSS followed by greensand filters to remove iron and/or manganese. Multi-media filters remove suspended particles by filtration using several layers of filter media, which usually consist of coarse anthracite coal above various gradations of finer silica sand. When the filter bed becomes loaded with suspended matter, it is backwashed with treated water to remove the solids deposited on the filter media. In the case of greensand filtration, dissolved iron and/or manganese is oxidized to the insoluble iron hydroxide and/or manganese oxide forms by contact with a chemically treated filter media called manganese greensand. The insoluble iron hydroxide and/or manganese oxide along with particulate metals in the groundwater are then filtered by the greensand media, and is removed by backwashing. When the oxidizing capacity of the greensand media is exhausted, the filter bed is regenerated with a weak potassium permanganate solution, thus restoring the oxidizing capacity of the bed.

Table 3.4-2
Henry's Law Constants for Volatile Compounds of Concern
Southeast Rockford Site
Rockford, Illinois

Compound	Henry's Law Constant @25°C
<i>cis</i> -1,2-Dichloroethene	0.067
<i>trans</i> -1,2-Dichloroethene	6.56E-3
PCE	0.22
TCE	0.116
1,1,1-TCA	0.172
1,1-Dichloroethene	0.4
1,1-Dichloroethane	5.45E-3

Reference: Clark and Adams 1991

An alternative approach to pretreatment equipment may be the use of proprietary chemical complexing agents that prevent metals from precipitating in the air stripping tower. The need for pretreatment should be explored during the remedial design phase and the appropriate combination of pretreatment steps identified. In any event, pretreatment costs should be covered within the cost estimation range (+50 percent to -30 percent) used in the detailed analysis.

Air stripping is an effective and relatively low-cost process option to remove VOCs from groundwater and is therefore retained for further discussion.

Tray Aeration

Tray aeration is a process variation of the transfer of contaminants from water to air. In this option, the pumped groundwater is aerated prior to cascading over a series of trays or baffles. As the supersaturated water releases air, the VOCs partition into the gaseous phase and are removed from the process for further off-gas treatment.

Tray aeration has the same pre- and post-treatment concerns as does air stripping. Further, if metals and carbonate (CO_3^{2-}) were removed by a coagulation/sedimentation process, the sludge generated by coagulation would require disposal, perhaps in a Resource Conservation & Recovery Act (RCRA) type landfill.

Since a representative process (air stripping) has already been retained, and since tray aeration is not sufficiently different from air stripping to warrant separate discussion, this process option is not retained for further evaluation.

Off-Gas Treatment

Off-gas treatment is used to remove the contaminants from a vapor stream prior to discharge to the atmosphere. A variety of methods may be used to treat the off-gas:

- Thermal destruction units
 - Vapor combustion
 - Catalytic oxidation
- Carbon adsorption unit
- Vapor condensation
- Wet scrubbers

More than one off-gas treatment method may be necessary if the concentration of the contaminant varies by an order of magnitude, across the Site or over time.

Thermal Destruction Units — The primary advantage of thermal destruction is that the contaminant is chemically altered so that it is no longer toxic. Vapor destruction units are typically used for contaminant concentrations >12,000 ppmv; catalytic oxidation is typically used for contaminant concentrations <12,000 ppmv. Vapor/liquid separators are used prior to thermal destruction units.

Vapor destruction units are employed for vapor streams with high concentrations (>12,000 ppmv) of organic contaminants. The advantages of vapor combustion units include simple operation and high compound destruction efficiencies. However, based on preliminary

calculations, off-gas concentrations will be substantially less than the 12,000 ppmv for vapor destruction. Therefore, vapor destruction was not retained.

Catalytic oxidation is effective on hydrocarbon vapors at concentrations less than 12,000 ppmv. Recently developed catalysts permit efficient destruction of halogenated compounds as well. The catalytic oxidation unit operates by preheating the vapor before entering the burner. The heated gas passes through the catalyst bed where it is oxidized. The catalyst accelerates the rate of oxidation and allows oxidation to occur at lower temperatures than thermal incinerators by adsorbing oxygen and the contaminant on the catalyst surface where the reaction produces carbon dioxide, water, and hydrochloric gas.

Chlorinated hydrocarbons may generate hydrochloric gas that may require removal by a scrubber, increasing the cost of treatment. In addition, hydrochloric gas may damage the catalyst. The off-gas streams generated at the Southeast Rockford Site are unlikely to be sufficiently concentrated to incur problems with hydrochloric gas, thus this technology will be retained for further consideration.

Carbon Adsorption Units — Activated carbon adsorption is the most commonly employed vapor treatment process. Carbon adsorption is typically used when contaminant concentrations are less than 1,000 ppmv. Although carbon adsorption has high removal efficiencies and is effective for most vapor streams, there are a number of disadvantages associated with its use:

- The contaminant is not degraded.
- Carbon must be regenerated or disposed of off site.
- Efficiency is degraded by moisture in the gas phase.
- The process is expensive.

Despite its disadvantages, carbon adsorption units compare favorably to other off-gas treatment processes and will be retained for further evaluation.

Vapor Condensation Units — Vapor condensation units may be used when the concentration of the contaminant is high and the flow rate is low. Condensation is typically accomplished by refrigeration; its effectiveness is determined by the vapor pressure and temperature characteristics of the contaminants present. Because condensation of the contaminant(s) is rarely complete, an additional method of treatment is typically required.

The vapor stream contaminant concentrations at the Southeast Rockford Site are not predicted to be sufficiently concentrated to warrant a vapor condensation unit, thus it will not be considered further.

Carbon Adsorption

Another process option for organics removal from groundwater is activated carbon adsorption. This technology is currently considered by EPA to represent the BAT, along with air stripping, for the removal of all VOCs except vinyl chloride (VC) (Love and Eilers 1982; Clark and Adams 1991). This option is widely used for the removal of both volatile and nonvolatile organic compounds. Activated carbon adsorption is most often carried out in a vessel that contains a bed

of granular activated carbon. Figure 3.4-2 shows a typical downflow activated carbon filter. Contaminated water enters the vessel and is evenly distributed over the granular activated carbon. As contaminated water flows through the activated carbon media, organic compounds are adsorbed onto the microporous surfaces of the activated carbon by an electrical attraction. When the carbon's micropores become saturated with adsorbed organics, the carbon must be replaced with new or thermally regenerated carbon media. Operating time before carbon exhaustion is a function of both the flow rate and the concentration of organic compounds in the feed stream.

The performance of activated carbon absorbers depends, in part, on the concentration of suspended solids in the influent stream. High concentrations of suspended solids and oxidized iron, if not removed, will plug the carbon media and negatively affect system hydraulics. As a result, multi-media filtration or clarification/equalization to remove suspended solids may be required as pretreatment to activated carbon. The cost involved in changing out the carbon at bed exhaustion and disposal of the spent carbon as hazardous waste are negative impacts of using activated carbon as a process option.

Activated carbon adsorption is a surface attraction phenomenon influenced by the physical properties of the carbon and contaminant compounds and system characteristics such as dissolved solids concentration, water temperature, and pH. The combined quantitative effect of these factors can be expressed by the Freundlich adsorption equation, in which the amount of compound adsorbed per unit mass of carbon is equal to a constant (K) multiplied by the final concentration of the compound after treatment and raised to the power of another constant (n). Both K and n, known as Freundlich parameters, are determined empirically on a compound-specific basis. Table 3.4-3 shows the Freundlich adsorption parameters K and 1/n for the COCs at hypothetical contaminant concentrations of 1.0 mg/L and a neutral pH.

Due to relatively high K values (>1.0) shown for most of the contaminants at the Site, it is expected that activated carbon would be an effective groundwater treatment technique. However, due to relatively high operations and maintenance (O&M) costs when compared to air stripping and because the organic contaminants at the Site would be more readily volatilized than adsorbed, for the purposes of alternative evaluation, carbon adsorption will be dropped in favor of air stripping as the primary method of organics removal.

UV/Chemical Oxidation

The chemical destruction of organic compounds through oxidation is a common practice in many industrial processes and has recently been adapted to the hazardous waste remediation field. The process involves mixing the influent water with one or more chemical oxidizers, such as ozone and/or hydrogen peroxide, then irradiating the water with ultraviolet radiation to induce the breakdown of contaminants. As a result of these reactions, the organic compounds are reduced to less harmful compounds. An advantage of this process is that it does not generate significant air emissions or other residual waste which would require further treatment. This process is retained for further evaluation.

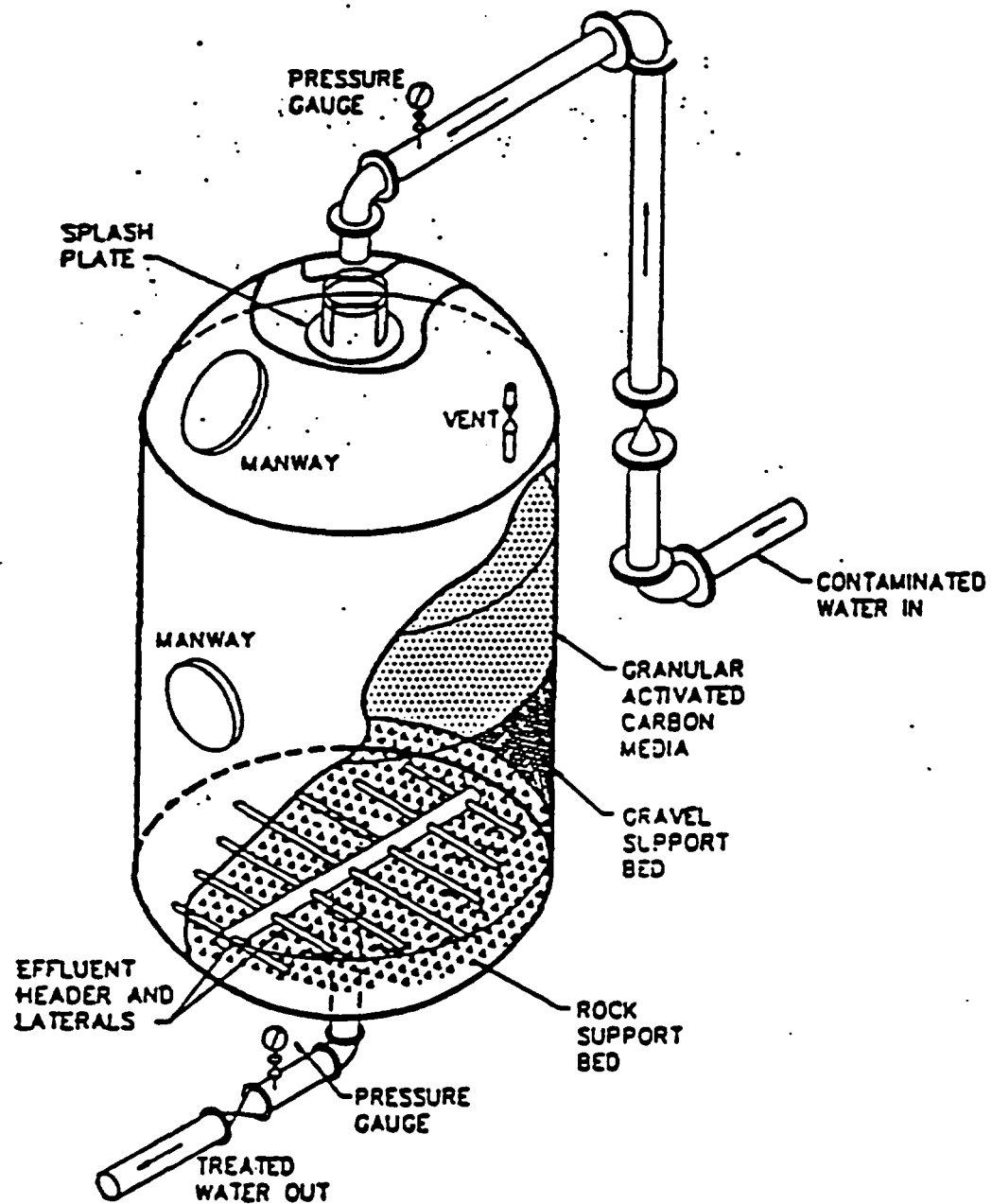


Figure 3.4-2 Typical Activated Carbon Filter

Table 3.4-3
Freundlich Parameter K Values for Contaminant Compounds^a
Southeast Rockford Site
Rockford, Illinois

Compound	Freundlich Parameter K at 1 mg/L (mg/adsorbed per gram of carbon)	Freundlich Parameter 1/n
<i>cis</i> -1,2-Dichloroethene	24.3	0.582
<i>trans</i> -1,2-Dichloroethene	38.5	0.39
Tetrachloroethene	341.2	0.516
Trichloroethene	95.0	0.484
1,1,1-Trichloroethane	29.7	0.495
1,1-Dichloroethene	51.1	0.515
1,1-Dichloroethane	64.6	0.706 µg/L ^b

^a Reference: Clark and Adams 1991b

^b Reference for 1,1-DCA: Speth and Miltner 1990

3.4.6.2 Biological Treatment

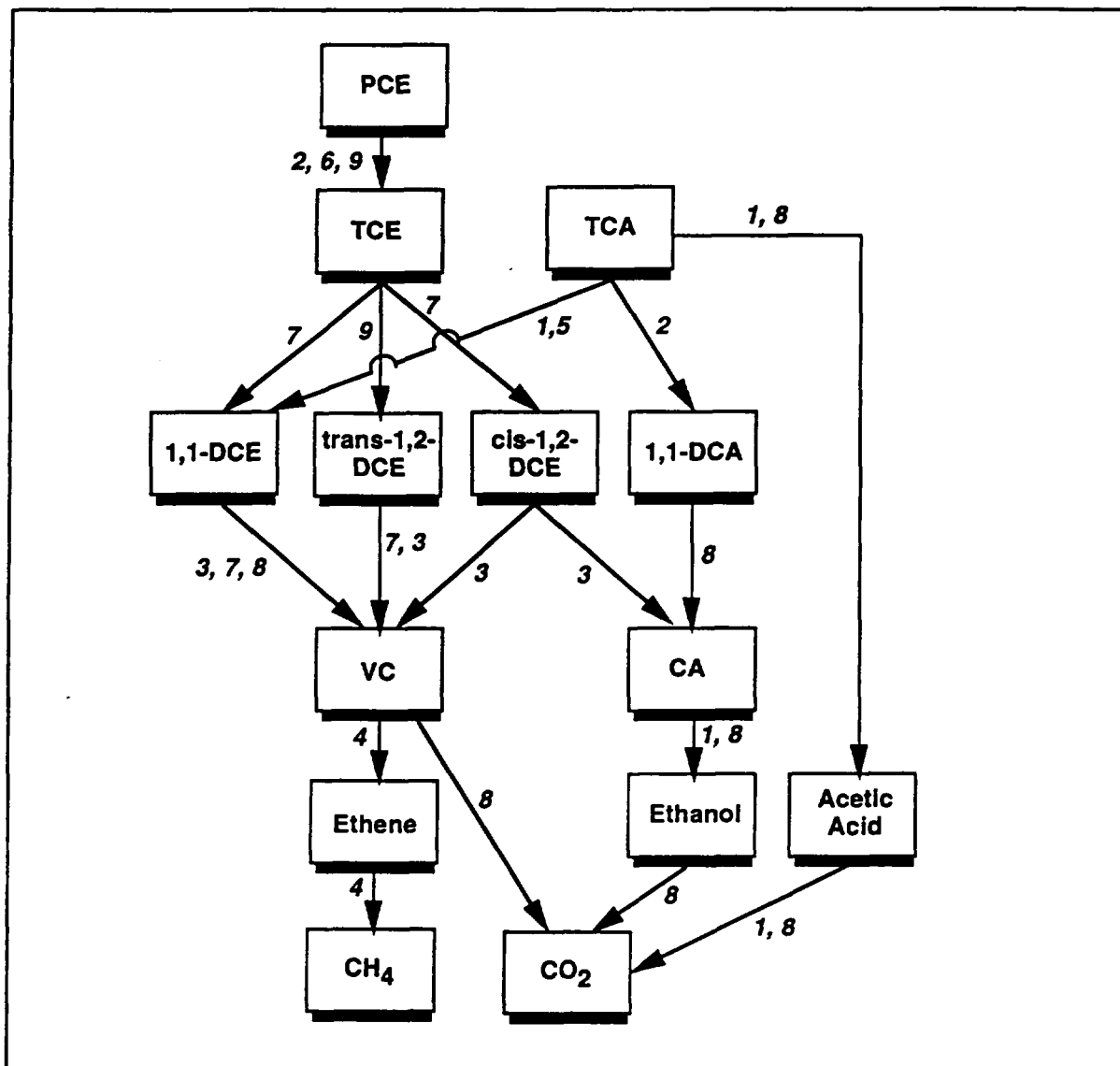
Bioremediation involves the use of microbiological processes to degrade compounds of concern by either anaerobic or aerobic pathways. The biological treatment can take place in a reactor under controlled conditions (i.e., direct treatment) or in-place under somewhat less direct control (i.e., *in situ* treatment). In either case, the biological mechanisms remain the same, only the operating conditions change. This section discusses the mechanisms involved in biodegradation, and the direct biological treatment technology. Section 3.4.5.3 discusses *in situ* bioremediation.

In most cases, halogenated aliphatic compounds are considered to be secondary substrates (i.e., substrates that are degraded but do not provide energy for the growth of the microbial population). Thus, for a secondary substrate to be degraded, an appropriate primary substrate, the source of energy and carbon for microbial growth, must be provided. In addition, an appropriate electron donor must be provided for anaerobic degradation. Similarly, an electron receptor must be provided for aerobic degradation. In general, the addition of halogens to an aliphatic compound increases its oxidation state and reductive potential. Thus, the more halogenated the aliphatic compound, the faster the relative rate of anaerobic reduction. Conversely, the more halogenated the aliphatic compound the slower the relative rate of aerobic oxidation. Both anaerobic and aerobic degradation mechanisms are discussed below.

Anaerobic Degradation

Methanogenic (methane-producing) bacteria facilitate reductive dechlorination of halogenated aliphatics under anaerobic conditions. PCE is sequentially reduced by microbes to TCE, then to either 1,1-DCE, *cis*- or *trans*-1,2-DCE. Both *cis*- and *trans*-1,2-DCE forms have been noted as the predominant degradation product of TCE at different sites. Which form predominates is potentially due to as yet undefined site specific conditions. Biotic formation of 1,1-DCE represents a minor pathway in TCE dechlorination. 1,1-DCE is also formed abiotically from chemical elimination of TCA. DCE forms are then reduced to VC, ethylene (ETH), and ultimately methane under anaerobic conditions. Biotic reductive dechlorination of 1,1,1-TCA results in 1,2-DCA and chloroethane (CA), which is abiotically transformed to ethanol (EtOH). The above transformations are summarized in Figure 3.4-3. Optimal conditions for anaerobic microbial degradation have been studied in the laboratory. Laboratory results are summarized below:

- Enhanced reductive dechlorination is not sustainable without addition of a primary substrate and an electron donor.
- Methanogens facilitate reduction reactions and can utilize methanol, glucose, acetate, hydrogen, or formate as an electron donor and/or primary substrate. Auxiliary substrates must be supplied in high concentrations, for example, acetate concentrations were 100 mg/L in several experiments.
- Alkylbenzenes, such as toluene or benzoate, can serve as electron donors for reductive dechlorination of chlorinated solvents. Current work shows that reductive dechlorination of TCE proceeds to ethene most readily when benzoate serves as the electron donor.



Explanation
1,1,1-TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
Cis-1,2-DCE = Cis-1,2-Dichloroethene
CA = Chloroethane
PCE = Tetrachloroethene
TCE = Trichloroethene
Trans-1,2-DCE = Trans-1,1-Dichloroethene
VC = Vinyl Chloride
1,1-DCE = 1,1-Dichloroethene

Path Reference
1 - abiotic pathway
2 - Bouwer 1983
3 - Barrio-Lage 1986
4 - Kuhn 1986
5 - Parsons, et al. 1982, 1983
6 - Vogel 1985
7 - Wood 1985
8 - Vogel and McCarty 1987
9 - Freedman and Gossett 1989

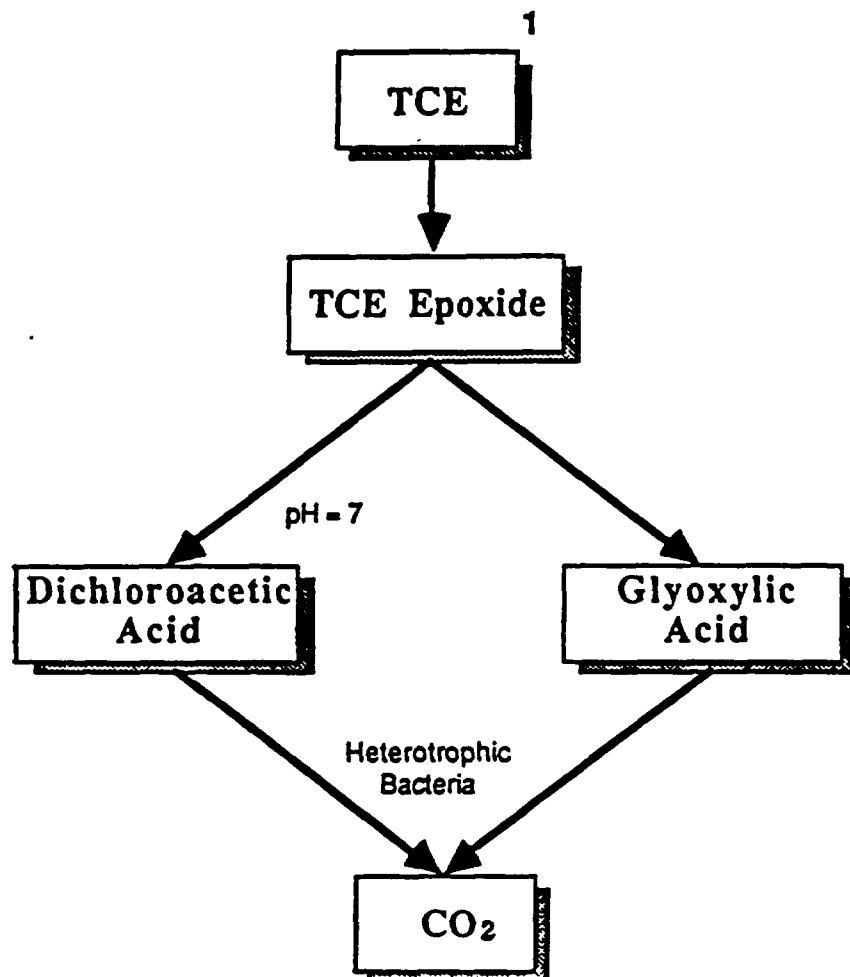
- PCE and 1,1,1-TCA were rapidly transformed to lesser chlorinated compounds under anaerobic conditions in the laboratory. For ethenes, the rate-limiting step is conversion of VC to ETH. Under optimal methanogenic conditions VC has been formed within 28 days in the laboratory. For ethanes, 1,1-DCA is recalcitrant, it does not readily degrade further under anaerobic conditions, though complete reduction to CO₂ has been observed.
- Recent research indicates that aerobic or facultative anaerobic bacteria may be involved in reductive dechlorination of PCE/TCE to *cis*-1,2-DCE while further dechlorination to vinyl-chloride is conducted by strictly anaerobic or methanogenic bacteria.
- A mixture of methanogenic microbes is preferable to pure cultures.
- High concentrations of sulfate (approximately 2.83 millimolar [mM] SO₄) inhibit methanogenesis and reductive dechlorination. Reductive dechlorination of PCE stops at 1,2-DCE under these conditions.

Aerobic Degradation

Methanotrophic (methane utilizing) bacteria co-metabolize chlorinated aliphatics under aerobic conditions when methane is available as the primary substrate. Conversion of methane to methanol utilizes molecular oxygen (i.e., aerobic), and is initiated by activation of the methane mono-oxygenase (MMO) enzyme. Once activated, the MMO enzyme also catalyzes formation of alkene epoxides from alkenes. Epoxides undergo abiotic transformations to nonvolatile compounds which are subsequently transformed by the consortium of heterotrophs to carbon dioxide, water, and chloride as shown in Figure 3 for TCE. The MMO enzyme can also oxidize alkanes to the corresponding alcohol and methyl ketone.

Some bacteria that utilize aromatic hydrocarbons, including phenol, toluene, and cresols, also are capable of degrading chlorinated aliphatic hydrocarbons under aerobic conditions. Research indicates that either a mono- or di-oxygenase enzyme which is activated during oxidation of the aromatic compounds can be responsible for oxidizing ethenes, potentially via formation of epoxide intermediates. Aromatic hydrocarbon utilizing bacteria can also degrade DCE and VC but not PCE under aerobic conditions. Laboratory results are summarized below.

- Methane and oxygen must be present to initiate and sustain degradation of chlorinated aliphatic compounds by methanotrophs. Certain aromatic hydrocarbons can induce aerobic degradation of chlorinated aliphatic compounds by oxygenase systems.
- VC, 1,2-DCE, and 1,1-DCA, are readily degraded by methanotrophs and by aromatic degrading bacteria. PCE is resistant to degradation by both types of microbial populations. 1,1,1-TCA and TCE are less easily degraded by methanotrophs than are the less chlorinated aliphatics, but aromatic hydrocarbon degrading bacteria are more active degraders of TCE than are methanotrophs.



1 - Little et al. 1988

Figure 3.4-4 Aerobic Methane Oxidizing Pathways for TCE

- At low cell concentrations, a product of TCE oxidation may be toxic to bacteria as evidenced by a decrease in the rate of degradation with time at low cell density (0.08 g/L). A rate decrease was not observed at high cell density (0.8 g/L) in the laboratory. Toxicity to the cells may be caused by the epoxide which can alkylate cellular nucleophiles (i.e., can substitute the epoxide into cellular compounds, altering their composition and function). This toxic effect does not appear to be present in the aromatic hydrocarbon system.
- Kinetics of chlorinated solvent biodegradation are dependent on competitive inhibition between substrate and chlorinated compounds. Pulsed addition of substrate has been demonstrated to reduce competitive inhibition.
- A mixed methanotrophic microbial community is required for complete degradation of chlorinated aliphatics to carbon dioxide, but the aromatic hydrocarbon system can facilitate complete mineralization by a single organism.
- Results indicate that aromatic-utilizing bacteria are more effective at degrading TCE, DCE, and VC than methanotrophs.

Recent research on aromatic-utilizing microbes has resulted in isolation of a bacterial strain, PR-1, which can degrade TCE using the same oxygenase enzyme system, without the addition of aromatic substrates (Personal communication 1992a). The PR-1 strain is currently being proposed by EPA for testing in the environment.

In summary, laboratory experiments and field research studies show that biodegradation of chlorinated aliphatics can be achieved aerobically via co-metabolism and/or anaerobically via reductive dechlorination.

The direct *ex situ* biological treatment of VOCs has been demonstrated in a number of tests. Hutton (1981) reported a 97 and 99 percent removal of PCE and TCE, respectively, by either an activated sludge process or a combination of powdered activated carbon plus activated sludge. The waste stream was generated by a large organic chemical manufacturing facility and varied from 23 to 50 million gallons per day (mgd). Meidl (1987) reported the removal of PCE and TCE at pilot-scale from the contaminated groundwater from the Stringfellow Quarry CERCLA site by the combined powdered activated carbon/activated sludge process.

For contaminated groundwaters, direct aerobic biological treatment has been demonstrated for TCE (EPA 1991). At Tinker Air Force Base, Oklahoma, approximately 80 percent removal of TCE was demonstrated at pilot-scale using methane. At Savannah River, South Carolina, 99 percent removal of TCE at pilot-scale was reported using propane; methane feed only reduced TCE by 50 percent. However, a submerged aerobic fixed-film reactor was reported to be ineffective at removing halogenated compounds.

Based on the above demonstrations, and the potential for accumulation of more toxic, lesser chlorinated compounds, direct anaerobic biological treatment was not retained for further analysis. Aerobic biodegradation was retained because of its effectiveness for the removal of all

the lesser chlorinated aliphatic compounds, and because it is the only biological destructive mechanism for complete removal of these contaminants.

3.4.6.3 *In Situ Treatment*

In situ treatment of a contaminant minimizes the need for above ground treatment. The *in situ* technologies evaluated for the Southeast Rockford Site include bioremediation and air sparging.

In Situ Bioremediation

In situ bioremediation involves the introduction of appropriate substrates or use of existing substrates and additives to enhance the capability of microorganisms to degrade in place the contaminants of concern. Substrates include primary food sources and cometabolites such as butyrate, tryptophan, toluene, phenol, or methane. Additives include oxygen, either as air, pure oxygen, or as dilute hydrogen peroxide (H_2O_2), to promote aerobic biodegradation, and, potentially, bacterial cultures to augment the naturally occurring organisms.

In situ biodegradation requires installation of either horizontal or vertical injection wells or trenches for addition of gaseous or liquid phase nutrients, electron acceptors/donors, and primary substrates that enhance growth of indigenous bacteria capable of degrading chlorinated aliphatics. Other factors that affect *in situ* biodegradation are:

- pH (near neutral is optimal) and buffering capacity of the aquifer
- Degree of saturation (particularly for treatment in the vadose zone)
- Hydraulic conductivity of the aquifer (for adequate delivery of injected compounds)
- Temperature
- Types and concentration of contaminants
- Distribution of contaminants
- Types and concentrations of existing electron donors
- Concentrations of metals that may precipitate under oxygenated conditions potentially clogging the aquifer

The Southeast Rockford Site has a high aquifer yield and therefore is suitable for injection of substrates required for biodegradation. Nitrate/nitrite concentrations range from less than 0.1 mg/L to 16.0 mg/L as N. The areas containing higher levels of N can support microbial populations without addition of supplemental nutrients. However, injection of high concentrations of electron acceptors/donors generally requires addition of supplemental nutrients.

Limitations to *in situ* biodegradation arise from alteration of the subsurface environment resulting in undesirable side effects such as:

- Precipitation of metallic oxides and hydroxides, particularly iron and manganese
- Plugging of the aquifer due to microbial growth
- Addition of substrates for microbial growth which are themselves detrimental to water quality, such as nitrogen compounds and aromatics

In addition, the Site geology, which includes the sorption of contaminants into the primary pores of the bedrock, combined with preferential flow through the fractures, would limit the ability to deliver nutrients to the microbial populations.

Field demonstration projects for *in situ* aerobic bioremediation have concentrated on stimulation of methanotrophic bacteria by injection of methane and oxygen to a subsurface aquifer. A study at the Moffat Air Force Base (Semprini 1990) demonstrated that biostimulation of endogenous methanotrophs with methane and oxygen resulted in biodegradation of 3 to 30 percent TCE, 46 to 58 percent *cis*-1,2-DCE, 58 to 76 percent *trans*-1,2-DCE, and greater than 95 percent VC at initial concentrations of 36 to 51 µg/L TCE, 50 to 136 µg/L each of *cis*- and *trans*-1,2-DCE and 44 µg/L VC. Plugging of the aquifer was successfully avoided by pulsing methane and oxygen addition and tests were reproducible over three years of testing. Phenol injection test results at the Moffat Air Force Base test site indicate that TCE and *cis*-1,2-DCE biodegradation rates are higher under phenol versus methane injection. Pulsed injection of 100 mg/L phenol for 1 hour over 8 hours (12 mg/L time weighted phenol concentration) resulted in 63 to 92 percent and 92 percent removal of TCE and *cis*-1,2-DCE, respectively. Higher removal rates of TCE were measured once co-injection of DCE with TCE was discontinued, potentially due to competitive inhibition. Lower *cis*-1,2-DCE and TCE removal (65 and 27 percent, respectively) were observed at lower (6.2 mg/L time weighted) phenol injection concentrations.

Two ongoing field demonstration projects are currently in operation at the Savannah River DOE Site. At one site, oxygen and propane or methane are injected to groundwater using a horizontal well. At a second sanitary landfill site, injection of air and methane for biodegradation of TCE and VC in the saturated zone will be pilot tested using vertical injection wells. Pilot tests are scheduled for the fall/winter of 1994/95. *In situ* testing of the aromatic degraders is ongoing at an active facility in northern California (Personal communication 1992d). Field testing of both *in situ* anaerobic and aerobic biodegradation is planned for a site in Kansas by early 1995 (Personal communication 1994). Results of the latter demonstration projects are currently not available.

In situ aerobic biodegradation by stimulation of methanotrophs can reduce VC to low levels, but treatment of TCE and DCE would require additional polishing steps to attain water quality standards. PCE cannot be treated aerobically and enhanced *in situ* anaerobic reduction of PCE has not been demonstrated in the field. Preliminary field results indicate that, if aromatic hydrocarbons such as phenol, toluene, or cresols are available in the subsurface, then biodegradation of TCE can be stimulated by addition of oxygen alone, for instance via air sparging. Alternatively, phenol-grown bacteria can be introduced into the subsurface with

oxygen and will catalyze the oxidation of TCE, DCE, and VC to carbon dioxide and chloride. *In situ* aerobic and anaerobic biodegradation were retained for further analysis as an innovative technology.

Air Sparging

Air sparging is a process that introduces air (oxygen) into the saturated zone, thus aerating the water. As the water is aerated, VOCs volatilize out of the water and into the air in the overlying unsaturated soil zone.

Air is injected into the saturated zone through a center well that is equipped with a blower or air pump. Surrounding wells equipped with vacuum pumps remove contaminated air from the base of the unsaturated zone. Once removed, the contaminated air stream is subjected to the same types of off-gas treatment processes discussed previously for air stripping. This technology would have limited application in a fractured bedrock environment, but could be used in unconsolidated areas of the plume. This process was retained for further evaluation.

3.4.6.4 Offsite Treatment

Offsite treatment remedial technologies involve the collection of contaminated water by extraction and the conveyance of the contaminated water to an offsite facility for treatment and disposal. Conveyance can be accomplished by pressure pipeline, gravity pipeline (e.g., sewer lines), or tanker truck.

The location of the offsite treatment facility is dependent on the quality of the contaminated water. If the quality is poorer than what is allowed to be discharged to a POTW, then the offsite treatment location would be a treatment/storage/disposal (TSD) facility permitted to accept RCRA wastes or to a permitted deep well injection facility. However, if the quality met the pretreatment limits established by the City of Rockford to protect its POTW, then the extracted groundwater could be discharged into a suitable sewer line. This flow would represent a capacity use of approximately 7 mgd. The maximum dry weather design limit for the City of Rockford POTW is 45 mgd. It is reported to be currently operating at between 28 and 32 mgd.

For any option that includes discharge of treated or untreated flows to the POTW, the hydraulic capability of the sanitary sewer system to accommodate these flows must be determined.

3.4.7 Discharge Technologies

Because the water treatment system design is dependent on the effluent criteria for the discharge of treated groundwater from the site, several discharge alternatives were considered. Discharge effluent criteria are presented in Table 3.4-4. Each discharge option is discussed and evaluated below.

3.4.7.1 Onsite Discharge

Onsite discharge technologies being considered for the Southeast Rockford Site include injection wells, infiltration basins, infiltration galleries, and spray irrigation.

Table 3.4-4
Effluent Criteria for Discharge Alternatives
Southeast Rockford Site
Rockford, Illinois

Contaminant	Surface Water Discharge (µg/L) ^a	Groundwater Discharge (µg/L) ^c	Discharge to POTW (µg/L)
Organics			
<i>cis</i> -1,2-Dichloroethene	b	70	d
<i>trans</i> -1,2-Dichloroethene	b	100	250
Tetrachloroethene	1,220	5	530
Trichloroethene	11,700	5	710
1,1,1-Trichloroethane	4,910	200	1,550
1,1-Dichloroethene	b	7	d
1,1-Dichloroethane	b	d	4,580

^a Acute daily average based on recently issued permits. Specific discharge requirements are determined as part of the discharge permit application process.

^b No current information available.

^c MCLs/IGWPA

^d No criteria

Injection Wells

Injection wells are used to inject treated water back into the aquifer. Injection wells have an advantage over other onsite discharge technologies in that they do not require much land to implement.

As discussed in Section 3.4.4.2, injection may occur either upgradient or downgradient of extraction. Upgradient injection can increase the hydraulic gradient, and increase extraction rates. Upgradient injection can be used to convey *in situ* treatment chemicals to the contaminated areas. These chemicals include oxygen (from air or from dilute hydrogen peroxide) to enhance aerobic biodegradation, nutrients to enhance biodegradation, oxidizers to promote chemical reactions, and surfactants for soil flushing. Downgradient injection can restore the aquifer to its pre-extraction hydrology.

Despite the multiple benefits of injection wells and their ease of implementation in general, this process has not been retained for further evaluation because of the constraints for implementation imposed by the State of Illinois and the infeasibility with respect to hydraulics, of reinjecting the volumes of water necessary to remediate the area into the existing aquifer.

Infiltration Galleries

Infiltration galleries consist of a perforated pipe in a trench filled with porous media. Treated water is discharged to the pipe where it percolates through the porous media and into the surrounding natural soils ultimately recharging the aquifer. Infiltration galleries can be employed either upgradient or downgradient following the rationale discussed above for injection wells. Although this option is more costly to construct than injection wells, the annual operating costs are lower. This option is retained for further analysis.

3.4.7.2 Offsite Discharge

Three options for offsite discharge of treated groundwater were evaluated for the Southeast Rockford Site. The options were offsite discharge to a POTW via the sanitary sewer collection system, surface water discharge via the storm sewer system, and reuse for potable and/or nonpotable purposes.

POTW Discharge

Discharge of treated groundwater to the POTW involves the same consideration of storm event hydraulic overloads as does offsite treatment at the POTW which was discussed previously in Section 3.4.5.4. POTW discharge was retained for further evaluation.

Surface Water Discharge via Storm Sewer

This option discharges treated groundwater to the Rock River via the existing stormwater collection system. The option is inexpensive and moderately implementable. Its effectiveness was rated as moderate because of the potential of a groundwater treatment process failure to introduce contaminated groundwater into the aquatic environment, although this potential can be minimized through proper engineering controls. The surface water discharge option was retained for further evaluation.

Reuse

Reuse options, whether potable or nonpotable, recognize the value of the treated groundwater in reducing the demand on the City's potable water supply. The two primary factors to be considered when evaluating reuse are the minimum demand for drinking water and the availability of storage. The treated groundwater maximum pump and treat represents 7 mgd of water which could further reduce demands on the City's raw water sources.

An advantage of potable reuse is the lack of a requirement for seasonal storage. Also, potable reuse would be able to accommodate all of the 7 mgd predicted to be available.

An advantage of potable reuse scenarios that connect directly to the distribution system is that the distances from treatment to potable system are generally substantially shorter than for nonpotable reuse scenarios. The disadvantage of potable reuse scenarios that connect directly to a drinking water distribution system is that each potable reuse stream would require a disinfection process prior to its introduction to the distribution system. In addition, each connection point would signify another point of compliance with drinking water regulations requiring continuing microbiological, inorganic chemical, and organic chemical monitoring. This variation of the potable reuse option entails additional monitoring, reporting, operations, maintenance, and materials handling concerns, but it was retained for further evaluation since it is compatible with the existing potable system.

Nonpotable reuse is a viable discharge alternative, especially when considered in conjunction with other discharge options. For example, the nonpotable reuse of treated water which would otherwise be discharged to the surface water can occur without the necessity of storage facilities. The small diameter pressure discharge lines would form the rudiments of a nonpotable distribution system. In lieu of storage, the treated waters would be diverted for discharge to surface water whenever insufficient nonpotable demand existed.

The reuse option specifically retained for further evaluation is the use of the groundwater, remediated to drinking water MCLs, for the augmentation of the City's potable water supply. In 1993, 6.4 billion gallons were pumped from the City of Rockford water supply wells. The 7 mgd of treated groundwater represents approximately 40 percent of the City's annual average drinking water production, that is equivalent to 17.5 mgd and could serve as the baseload supply.

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Section 4

4 section Four

Section 4

Development and Screening of Remedial Action Alternatives

The purpose of this section is to formulate alternatives for the retained no action, institutional controls, natural attenuation, collection, treatment, and discharge process options described in Section 3.4. The alternatives will then be screened based on a relative comparison between their expected short- and long-term effectiveness, implementability, and cost.

4.1 Development of Remedial Action Alternatives

In assembling remedial action alternatives, the retained process options under the general response actions are combined to address site-wide groundwater contamination. Based on the evaluation of the retained process options, the contaminated groundwater would either be allowed to naturally attenuate, contained, extracted and treated on or off the Site, or treated *in situ*. Process options remaining following the screening described in Section 3 included:

- **No Action:** Including continued groundwater monitoring of both existing wells to evaluate plume migration and/or degree of cleanup, and of newly installed wells along the Rock River to ensure protection of the environmental receptor (Rock River)
- **Natural Attenuation:** Combined with other options, may be feasible for restoring groundwater
- **Institutional Controls:** Water utility service expansion; use restrictions, including groundwater use restrictions, deed restrictions, and access restrictions; and continued groundwater monitoring
- **Containment:** Hydraulic controls are discussed under extraction
- **Treatment:** Treatment by air stripping with off gas control, biological and offsite T/S/D facility
- **Disposal:** Disposal offsite to surface water, or offsite to POTW, or for potable reuse

These process options were combined to create four basic alternatives for the Site. Process options contained within the alternatives are shown in Table 4.1-1.

The four alternatives under consideration are listed in Table 4.1-2. Alternatives were developed to span as great a range of NCP categories as possible. The NCP categories (55 Federal Register 8848) are summarized in Table 4.1-3. All options assume that Municipal Well UW35 will remain an active well. Well UW35 was remediated as a separate OU during a previous remedial action. The water in Well UW35 is treated to MCLs with a GAC contactor. In addition, the remedial alternatives are intended to address only groundwater. Individual source areas, including contaminated soil and any NAPLs present, will be considered under separate OUs as part of future feasibility studies.

**Table 4.1-1
Groundwater Remedial Action Alternatives**

Technology Type	General Response Actions					
	1 No Action	2a Use Restrictions Institutional Controls	2b Limited Action Groundwater Extraction, Natural Attenuation, Treatment, Offsite Discharge	3a Groundwater Extraction, Treatment, Offsite Discharge to Surface Water for Entire Site	3b Groundwater Extraction, Treatment, Onsite Discharge to Potable System for Entire Site	4 <i>In Situ</i> Bioremediation
Monitoring	X	X	X	X	X	X
Use Restrictions		X	X	X	X	X
Natural Attenuation	X	X	X	X	X	
Extraction Wells			X	X	X	X
Treatment Air Stripping Biological			X a	X a	X a	X
Disposal Onsite Offsite			— X	X	X	X
NCP Category	5	2	1, 2, 3, 4	1, 3, 4	1, 3, 4	3

Natural attenuation, a suboptimal form of *in situ* biological treatment, will be considered as a component of all treatment alternatives. It will be modeled as a first order decay process. Facilitated *in situ* bioremediation could supplement naturally occurring and active remediation of the groundwater. However, due to the complexity of the site's geology and the heterogeneity of the contaminant distribution, modeling and costing will not be performed.

Table 4.1-2
Remedial Action Alternatives
Southeast Rockford Site
Rockford, Illinois

Alternative Number	Description
1	No Action Long-term monitoring
2a	Use Restrictions — Institutional Controls Public education Long-term monitoring Institutional controls
2b	Limited Action — Remediation of a Limited Area with Offsite Discharge Public education Long-term monitoring Institutional controls Installation of limited extraction system Construction of groundwater treatment system (air stripping) Natural Attenuation Offsite discharge: a) POTW; b) surface water
3a	Groundwater Extraction and Air Stripping with Offsite Disposal — Remediation of Entire Site Public education Long-term monitoring Installation of extraction system Construction of groundwater treatment system (air stripping) Offsite discharge to surface water Institutional controls
3b	Groundwater Extraction and Air Stripping with Offsite Discharge — Remediation of Entire Site Public education Long-term monitoring Installation of extraction system Construction of groundwater treatment system (air stripping) Offsite discharge to potable system Institutional controls
4	<i>In Situ</i> Bioremediation (Anaerobic/Aerobic) Public education Long-term monitoring Implementation of treatability study (bench- and pilot-scale studies) Installation of extraction system Construction of inoculation/reinjection system Offsite discharge: a) POTW (residuals); b) surface water (effluent) Institutional controls

Table 4.1-3
Summary of NCP Alternative Categories
Southeast Rockford Site
Rockford, Illinois

NCP Category	Description
1	Alternatives that, as their principal element, employ treatment that reduces toxicity, mobility, or volume of the contaminants. Alternatives that remove or destroy contaminants to maximum extent, eliminating or minimizing long-term management.
2	Alternatives that minimize the principal threats but involve little or no treatment. Protection would be by prevention or control of exposure through engineering and institutional controls.
3	Alternatives that include innovative treatment technologies.
4	For groundwater activities, alternatives that attain site-specific remediation levels within different time periods, using one or more different technologies.
5	No-action alternative.

Alternative 1 for the Southeast Rockford Site addresses NCP Category 5, consisting of no action but including groundwater monitoring. This alternative will be evaluated in accordance with the NCP to establish baseline conditions against which other remedial actions may be compared. Alternative 2 consists of limited action and addresses NCP Category 2 by preventing exposure to the contaminated groundwater through the use of institutional controls. Alternative 3, and the limited groundwater treatment component of Alternative 2b, combine groundwater extraction and onsite treatment. These alternatives address NCP Category 1 by reducing contaminant toxicity, mobility, or volume. *In situ* biological treatment will be considered as a component of Alternatives 2, 3, and 4 satisfying NCP Category 3 by utilizing an innovative treatment technology. Finally, Alternatives 2 through 4 also address NCP Category 4 which includes those alternatives that attain remediation levels within different time periods.

4.2 Screening of Remedial Alternatives

This subsection presents a detailed description and evaluation of the previously developed remedial action alternatives. Each alternative's short- and long-term effectiveness, implementability, and cost were evaluated for comparison purposes. The criteria for the alternatives evaluation are defined by the NCP as follows:

- **Effectiveness.** The degree to which an alternative reduces toxicity, mobility, or volume through treatment; minimizes residual risks; affords long-term protection; complies with ARARs; minimizes short-term impacts; and can be implemented in a timely manner. Significantly less effective alternatives that do not provide adequate protection of human health and the environment will be eliminated from further consideration.
- **Implementability.** The technical and administrative feasibility of implementing an alternative. Alternatives that are technically or administratively unfeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time may be eliminated from further consideration.
- **Cost.** The costs of construction and any long-term costs to operate and maintain an alternative. Alternatives providing effectiveness and implementability similar to that of other alternatives, but at greater cost, may be eliminated. Costs that are grossly excessive compared to the overall effectiveness of alternatives may be considered as one of several factors to eliminate an alternative. In this screening phase, costs are estimated to be accurate in the range of +100 percent to -50 percent. Because of this range, and the use of a fixed 50-year time span for the calculation of present worth, cost estimates may not match detailed estimates developed in the next section.

After each criterion is evaluated, remedial alternatives with the most favorable overall evaluations are retained and will undergo detailed analysis in Section 5. The screening procedure attempts to maintain representative alternatives from the full range of no action, institutional controls, extraction, containment, treatment, and discharge technologies and process options applicable to the contaminated groundwater at the Site.

Cost estimation for the remedial action alternatives was performed using standard CDM cost estimating procedures. Assumptions made for costing purposes include:

- **Monitoring:** Quarterly Sampling for VOCs for the following wells shown on Figure 4-2.1a:
 - Existing wells MW117A,B,C; MW119; MW121; MW123; MW124; MW127; MW130; MW113A,B; MW114A,B; MW16, MW31, MW101A,B,C,D; MW102A,B,C, MW133A,B,C; and MW136.
 - Eight new monitoring and/or extraction wells (PW1 on Figure 4.2-1a).
 - One new monitoring well MW200 located east (upgradient) of the residential area that is not currently targeted for connection to the Utility Service.
- **Water utility service:** Expansion of existing water utility service mains within the area determined to be affected by the existing, and predicted 70 year, MCL plume and connections to the mains for potable water users within the area shown on Figure 4-2-1a.
- **Public education:** The quarterly mailing of approximately 600 two-color inserts, public meetings and news releases.
- **Extraction:** Consists of pumps, connecting piping, equalization basin, air stripper (includes pump, blower, tower, media), off gas treatment (if required), and discharge line (to surface water, POTW, or reuse).
- **Bioremediation:** Consists of pumps, blowers and basins. May require addition of carbon source or nutrients. Biosolids residuals discharged in POTW. Effluent discharged to surface water.
- **Period of remediation:** The calibrated groundwater model was used to develop estimates of remediation timeframes. Assumptions were applied to the modeling runs with respect to source cleanup. The details of the FS modeling are provided in Appendix C. The length of time used for costing purposes is the upper limit of the range determined to be required to remediate the Site with the sources being turned off as described in Appendix C. The groundwater modeling indicates that if it is assumed that the sources are not remediated cleanup times that are as much as 200 years longer than the estimated cleanup times with the sources controlled.
- **For all treatment alternatives:** Effective control of source areas of contamination including NAPLs occurs prior to or coincident with remediation activities. However, source control will occur under separate response actions.

The details of the design of the air strippers and off-gas treatment are contained in Appendix B.

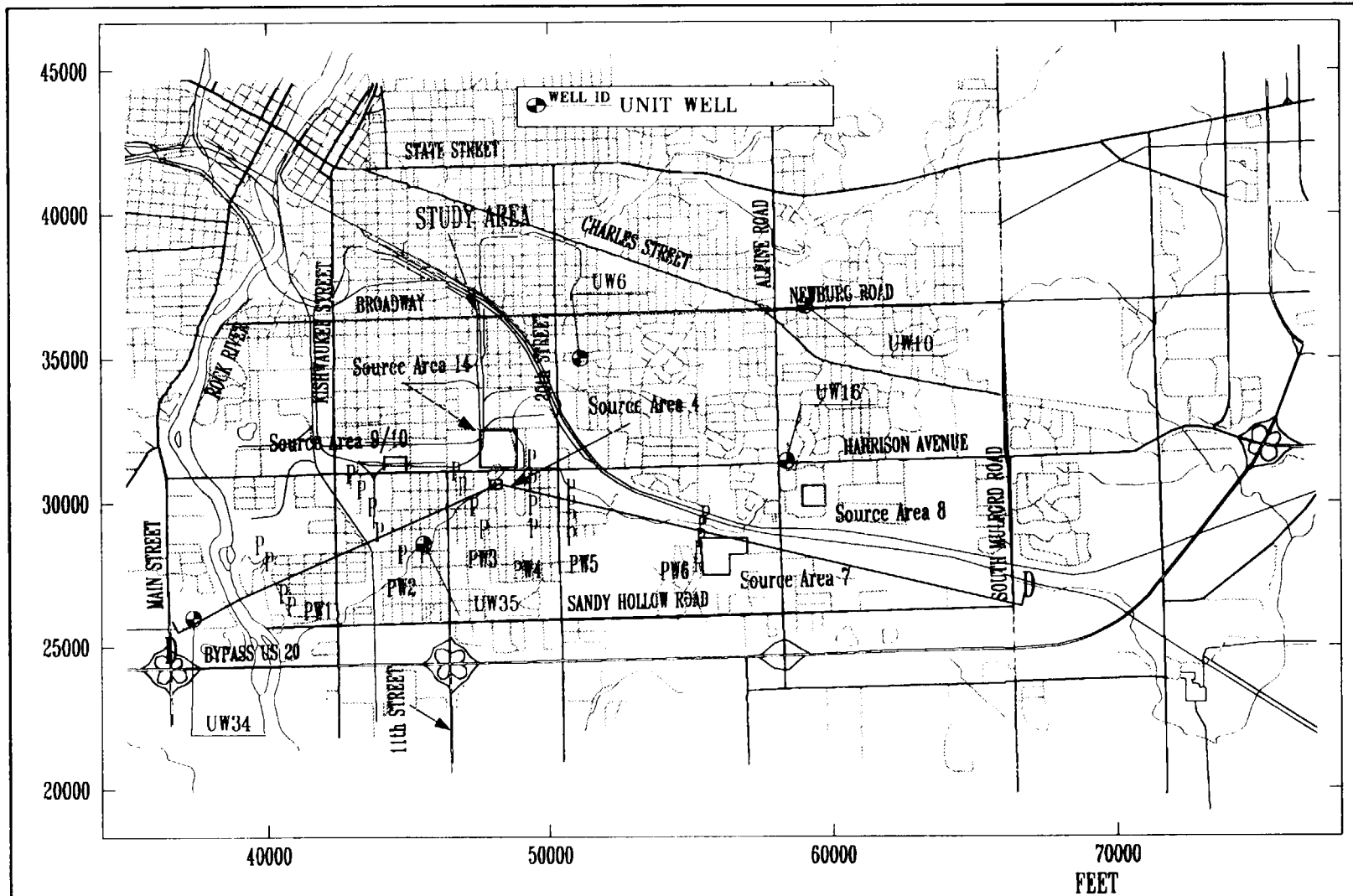


FIGURE
4.2-1

SOUTHEAST ROCKFORD FEASIBILITY STUDY
Proposed Locations for Extraction Network Wells

CDM

environmental engineers, scientists,
planners, & management consultants

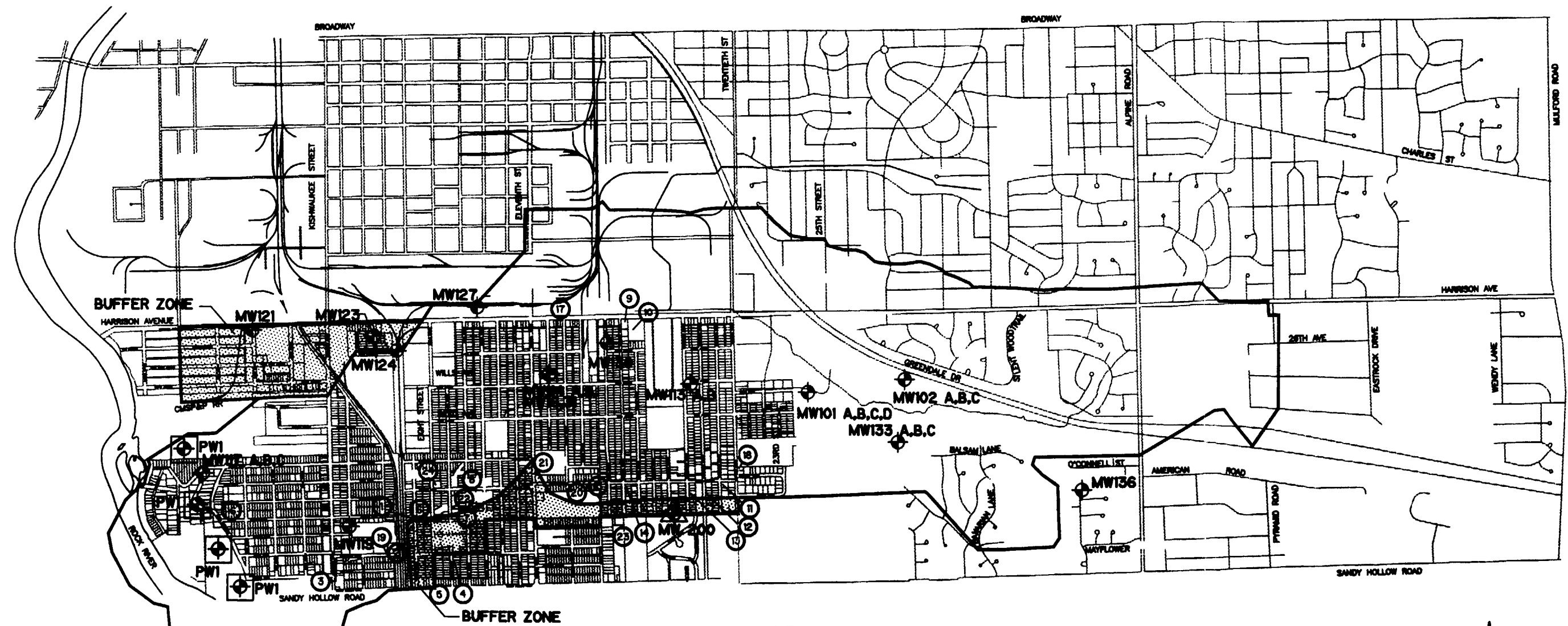
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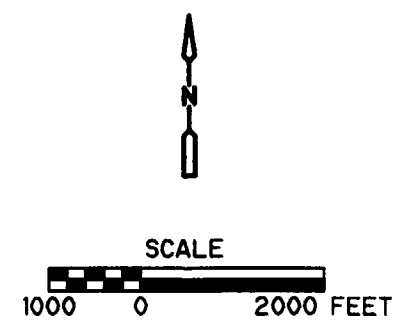
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NOTE:
AREAS PROPOSED FOR CONNECTION TO PUBLIC WATER SUPPLY
INCLUDES RESIDENCES WITHIN PROJECTED 5 ppb CONCENTRATION LINE
AND WITHIN THE BUFFER ZONES

LEGEND

-  EXISTING MONITORING WELL
 -  NEW MONITORING WELL
 -  NEW WELL - MONITORING AND /OR EXTRACTION
 -  RESIDENTIAL WELL SAMPLED IN 1993
- ADAPTED FROM FIGURE 6-2
REMEDIAL INVESTIGATION REPORT 1 / 95



environmental engineers, scientists,
planners, & management consultants

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
70 YEAR PROJECTED 1,1,1-TCA - 1,1-DCA
CONTAMINANT PLUME AND BUFFER ZONE

Figure No. 4.2 - 1A

4.2.1 Alternative 1 — No Action

This alternative does not involve any construction or remediation other than the installation of eight additional monitoring wells at four locations one mile upgradient of the eastern bank of the Rock River and of Well MW 200. Long-term quarterly groundwater monitoring for 205 years of these nine wells and at 25 existing wells located across the Site will be the only action taken within the OU under this alternative. This alternative is required by the NCP to be carried through screening processes, as it serves as the baseline for comparing remedial action alternatives.

Effectiveness

This alternative does not reduce contaminant mobility, toxicity, or volume; nor does it minimize risks to the environment or human health or provide long-term protection over an extended period of time (at least 205 years), natural attenuation will result in aquifer restoration assuming the sources are controlled. This alternative will comply with ARARs at the point in time the aquifer is naturally restored.

Implementability

Long-term monitoring can be easily and immediately implemented.

Cost

The overall capital and O&M cost estimates for implementing Alternative 1 are presented in Table 4.2-1. The total present worth costs (at 5 percent for 205 years) are approximately \$1.35 million.

The no-action alternative is retained (required by NCP).

4.2.2 Alternative 2a — Use Restrictions

This alternative includes the following institutional controls to restrict the use of contaminated groundwater: (1) long-term quarterly groundwater monitoring of new wells adjacent to the Rock River, at Well MW200 and at 25 existing monitoring wells located across the Site, (2) public education to discourage the use of groundwater for drinking or bathing, and (3) restriction on the use of groundwater for potable purposes by way of expanding to the water Utility System.

The new monitoring wells located just east of the Rock River will monitor progress of the plume and provide an indication of any potential impacts to the river. MW200 will be installed to monitor plume movements upgradient of residents using groundwater for potable purposes. If contamination is detected in this well, additional actions will be evaluated such as residential well monitoring and additional hook-ups. Existing monitoring wells will be used to evaluate plume movement over time and to evaluate the effectiveness of implemented remedial actions.

Public education will be implemented through the use of fact sheets, public meetings, and local news media announcements. Use restrictions are the only method available to protect the public health during the implementation of the remedial action. This period has been predicted to be 205 years. Therefore, use restrictions are considered to be a component of each remedial action

Table 4.2-1
Screening Cost Estimate for Alternative 1
SE Rockford Site
SE Rockford, Illinois

Alternative	Item	Estimated Cost
1. No Action (Long-Term Monitoring)	Monitor Well Installation	25,000
	Long-Term Groundwater Monitoring	<u>800,000</u>
	Preliminary Subtotal	825,000
	Contractor, Legal, and Engineering Fees (30 percent of Capital Cost)	<u>250,000</u>
	Subtotal	1,075,000
	Contingency (25 percent of Subtotal)	<u>270,000</u>
	Total Present Worth Cost	1,345,000

as presented in Table 4.1-1. Restrictions on the potable use of groundwater for all users within the area of concern would require cooperative action between the water provider, the City, the Winnebago County Health Department, the IDPH, and the IEPA as presented in Section 3.4.2.1.

The primary goal of this alternative is to protect human health. The aquifer will not be actively restored to drinking water quality, but passive restoration is expected to occur over an extended period time, once the sources are controlled. Because this restoration of groundwater is expected to be a long term remedial action, (i.e., 205 years) that is the period over which compliance with ARARs will occur.

For the purposes of costing, an estimate of the number of additional connections to the Utility System that would be required to protect the public health was made. To develop a basis for estimating extension of the water mains to connect potable groundwater users to the Utility System, the following information sources were used:

- The results of an address verification survey conducted by CDM during the remedial investigation and residential well sampling task
- The results of a well survey conducted by IEPA in the study area
- A map of incorporated and unincorporated areas of the City
- Water distribution system maps provided by the City of Rockford
- Maps illustrating the water main extension project that was implemented by EPA
- Private well water quality data collected during the remedial investigation phase, and other data provided by EPA and IDPH

The preceding sources were used to determine target addresses in the study area that are currently not serviced by city water and that lie within the boundaries of the existing and 70 year predicted groundwater contamination plumes where contaminants exceed MCLs for the target compounds. A "buffer zone" was created by extending the proposed water mains to the next sampled well outside of the existing, and the 70 year predicted MCL plume boundaries and completing the water delivery system to the end of the block where that well is located. Based on this evaluation, a total of approximately four miles of water main and 400 individual connections were used for costing purposes. Figure 4.2-1a presents the extent of the proposed connections to the Utility System.

Effectiveness

This alternative does not reduce contaminant mobility, toxicity, or volume. It does lessen risks to human health by administrative control and by public education. It does not otherwise provide long-term protection. As previously stated, natural attenuation of the contamination in the groundwater will result in compliance with ARARs at the point in time the aquifer is naturally restored (approximately 205 years).

Implementability

The monitoring and public education aspects of this alternative can be easily implemented. Public education will be a continuous process which may require about six months to get implemented. As described above, the implementation of use restrictions will likely require a cooperative and coordinated effort by local and state agencies. This effort may require about a year to implement.

Cost

The overall cost estimates for implementing Alternative 2a are presented in Table 4.2-2. The total present worth cost (at 5 percent for 205 years) is approximately \$3.79 million. Alternative 2a is retained for further analysis.

4.2.3 Alternative 2b — Limited Action

This alternative includes all of the institutional controls discussed for alternative 2a and, in addition, includes the installation of pumping wells with an air stripping treatment system within the plume.

The pumping wells and treatment system will be designed to remediate a limited area only. The pumping wells will be placed east of 20th Street (at the location of the PW4 network on Figure 4 and will be operated at approximately 1,000 gallons per minute (gpm). Offsite discharge will be evaluated for this alternative. Coupled with the air stripping treatment system designed to remediate a limited area, this alternative also evaluates the degree to which natural attenuation restores the aquifer to drinking water quality. The goal of this alternative is to protect human health and to restore the aquifer using a combination of active and passive technologies. Because restoration of the groundwater is expected to be a long term remedial action, (i.e. at least 125 years), that is the period over which compliance with ARARs will occur.

Effectiveness

Alternative 2b reduces contaminant mobility, toxicity, and volume for the entire site over an estimated period of between 75 and 125 years based on the calibrated groundwater model for 1,1,1-TCA. This alternative lessens risks to human health by administrative control, public education, and limited treatment. As described in Appendix C, this alternative will comply with ARARs at the time of completion, however, the estimated timeframe as determined from the model is for 1,1,1-TCA to reach its MCL. Additional clean-up time may be necessary for other more persistent compounds such as PCE and TCE to reach their MCLs.

Implementability

Computer modeling has been performed to determine the placement of the extraction wells, the pumping rates, and the duration of the system operation. Pilot testing is required to validate design criteria. Adequate maintenance and proper personnel training is required for optimum system performance. Permit requirements would be met prior to offsite discharge.

Table 4.2-2
Screening Cost Estimate for Alternative 2a
SE Rockford Site
SE Rockford, Illinois

Alternative	Item	Estimated Cost
2a — Use Restrictions	Monitor Well Installation	25,000
	Groundwater Monitoring	800,000
	Public Education	150,000
	Water Utility System Expansion	<u>1,500,000</u>
	Preliminary Subtotal	2,325,000
	Contractor, Legal and Engineering Fees (30 percent of Capital Costs)	<u>700,000</u>
	Subtotal	3,025,000
	Contingency (25 percent of Total)	<u>760,000</u>
	Total Present Worth Cost	3,785,000

Cost

The overall costs for implementing Alternative 2b are presented in Table 4.2-3. The total present worth costs (at 5 percent for 125 years) are approximately \$12.46 million.

4.2.4 Alternative 3a — Groundwater Extraction and Air Stripping with Offsite Disposal

This alternative combines all of the components of Alternatives 1, 2a, and 2b with the following technologies to address removal and treatment of all contaminated groundwater within the OU.

- Recovery of contaminated groundwater via extraction wells
- Treatment of extracted groundwater via air stripping for reduction of VOCs
- GAC or thermal destruction of off gas as required
- Offsite disposal of treated groundwater to surface water

As with Alternatives 2a and 2b, this action, is protective, and will comply with ARARs at the completion of the response action. Because restoration of groundwater is expected to be a long term remedial action (i.e. at least 75 years), that is the period over which compliance will occur.

The pumping scheme for this alternative includes five sets of pumping wells (PW1, PW2, PW3, PW5, and PW6 on Figure 4.2-1.) Table 4.2-4 shows the estimated pumping rate required for each of the five pumping well systems. Contaminant transport simulations for remediation of the Site groundwater to the 1,1,1-TCA, MCL indicate that between 25 and 75 years of pumping at a rate greater than 6,000 gpm is needed to achieve the MCL. Additional time may be necessary for other more persistent compounds, such as PCE and TCE to reach their MCLs.

Effectiveness

This alternative significantly reduces contaminant mobility, toxicity, and volume; minimizes risks to the environment and human health; and provides long-term protection. Compliance with ARARs has been predicted, based on modeling of 1,1,1-TCA to occur after 75 years of operation.

Implementability

Computer modeling has been performed to determine the placement of the extraction wells, the pumping rates, and the duration of the system operation.

Adequate maintenance and proper personnel training is required for optimum system performance. Permit requirements would be met prior to discharge.

Cost

The overall costs for implementing Alternative 3a with off-gas treatment via GAC are presented in Table 4.2-5. The total present worth costs (at 5 percent for 75 years) are approximately \$64.73 million. The cost of discharging the treated water to the POTW is \$0.10 per gallon, or \$700,000 per day. Therefore, only discharge to surface water and not discharge to the POTW will be considered for detailed analysis (Section 5).

Table 4.2-3
Screening Cost Estimate for Alternative 2b
SE Rockford Site
SE Rockford, Illinois

Alternative	Item	Estimated Cost
2b — Limited Action and Natural Attenuation	Monitoring Well Installation	25,000
	Groundwater Monitoring	800,000
	Public Education	150,000
	Water Utility System Expansion	1,500,000
	Limited Extraction/Treatment/Discharge	5,335,000
	Natural Attenuation	—
	Preliminary Subtotal	7,660,000
	Contractor, Legal, and Engineering Fees (30 percent of Capital Costs)	2,300,000
	Subtotal	9,960,000
	Contingency (25% of Subtotal)	2,500,000
	Total Present Worth Cost	12,460,000

Table 4.2-4
Remediation Pumping Wells
Southeast Rockford Site
Rockford, Illinois

Location	No. of Nodes	Total Pumping Rate (gal/min)
PW1	4	1,332
PW2	5	1,665
PW3	4	1,000
PW4	4	1,000
PW5	4	1,000
PW6	5	350
TOTAL		6,347

Table 4.2-5
Screening Cost Estimate for Alternative 3a
Southeast Rockford Site
Rockford, Illinois

Alternative	Item	Estimated Cost
3a — Groundwater Extraction and Air Stripping with Offsite Disposal to Surface Water	Monitoring Well Installation	25,000
	Groundwater Monitoring	800,000
	Public Education	150,000
	Water Utility System Expansion	1,500,000
	Full Extraction/Treatment/Disposal	<u>37,500,000</u>
	Preliminary Subtotal	39,825,000
	Contractor, Legal, and Engineering Fees (30 percent of Capital Costs)	<u>11,950,000</u>
	Subtotal	51,775,000
	Contingency (25 percent of Subtotal)	<u>12,950,000</u>
	Total Present Worth Cost	64,725,000

4.2.5 Alternative 3b — Groundwater Extraction and Air Stripping with Offsite Discharge

This alternative parallels Alternative 3a with the exception that the method of disposal of the treated water is for potable reuse. As with Alternative 3a, MCL for 1,1,1-TCA will be achieved after an extended (25 to 75 years) time period. Cleanup times for more persistent compounds may extend beyond this timeframe.

Effectiveness

The effectiveness of this alternative is the same as that described in Alternative 3a.

Implementability

The implementability of this alternative is the same as that described for Alternative 3a.

Cost

The overall costs for implementing Alternative 3b with off-gas treatment via GAC are presented in Table 4.2-6. The total present worth costs (at 5 percent for 75 years) are approximately \$24.69 million, based on the assumption that the treated water has a value and will be sold to the Utility System for reuse.

4.2.6 Alternative 4 — In Situ Bioremediation

The use of *in situ* bioremediation by both anaerobic and aerobic pathways will be evaluated as Alternative 4. This alternative either replaces the physical/chemical processes used in Alternatives 2 and 3 with *in situ* biological processes or supplements the physical/chemical processes. Bench- and pilot-scale studies will be required to determine implementability and effectiveness. Although this alternative is technically feasible, a complete evaluation cannot be performed without performing bench- and pilot-scale treatability studies. In addition, the geologic complexity of the Site may make introduction of biometer and nutrients to the aquifer infeasible. Therefore, this alternative is not retained for detailed cost analysis.

4.2.7 ARARs Waivers

Because of the long projected time frame over which remediation will occur for all alternatives, it may be prudent to consider whether the site meets established criteria necessary to waive ARARs. ARARs waivers can be granted under CERCLA for the following reasons:

- Interim remedy
- Greater risk to human health and the environment
- Technical impracticability
- Equivalent standard of performance
- Inconsistent application of state requirements
- Fund balancing

Three of these waivers may apply to this FS. These waivers and their potential use at the Site are explained below:

- **Interim Remedy.** An interim remedy can be part of the final remedy or it can be a partial remedy that is implemented while the final remedy is under construction or

Table 4.2-6
Screening Cost Estimate for Alternative 3b
Southeast Rockford Site
Rockford, Illinois

Alternative	Item	Estimated Cost
3b — Groundwater Extraction and Air Stripping with Offsite Discharge to Potable System	Monitoring Well Installation	25,000
	Groundwater Monitoring	800,000
	Public Education	150,000
	Water Utility System Expansion	1,500,000
	Full Extraction/Treatment/Disposal	<u>12,865,000</u>
	Preliminary Subtotal	15,190,000
	Contractor, Legal, and Engineering Fees (30 percent of Capital Costs)	<u>4,550,000</u>
	Subtotal	19,750,000
	Contingency (25 percent of Subtotal)	<u>4,940,000</u>
	Total Present Worth Cost	24,690,000

while the necessary arrangements for the final remedy (e.g., obtaining permits) are made.

- **Technical Impracticability.** Technical impracticability (TI) implies an unfavorable balance of engineering feasibility and reliability. The term "engineering perspective" used in CERCLA implies that cost, although a factor, is not generally a major factor in the determination of technical impracticability. This waiver may be used when neither existing nor innovative technologies can reliably attain the ARAR in question; or attainment of the ARAR is not practicable from an engineering perspective. For groundwater remedies, technical impracticability may be measured in terms of restoration time frame. A time frame beyond 100 years would generally warrant the technical impracticability waiver. EPA's *Guidance for Evaluating the Technical Impracticability of Groundwater Restoration* details the TI process.
- **Funding-Balancing.** The Fund-balancing waiver may be invoked when meeting an ARAR would entail extremely high costs in relation to the added degree of protection or reduction of risk afforded by that standard and when remedial action at other sites would be jeopardized (because of lack of funds) as a result.

4.3 Summary of Interim Remedial Action Alternatives Screening

During the initial alternatives development, alternatives were identified for Site remediation. These alternatives were analyzed on the basis of their effectiveness, implementability, and cost. The results of the alternatives screening evaluations are summarized in Table 4.3-1.

The "no action" alternative is retained as required by the NCP.

In summary, the retained alternatives and approximate screening level (+100 percent/-50 percent) costs are:

- 1 - No Action [\$1.35 million]
- 2a - Use Restrictions [\$3.79 million]
- 2b - Limited Action [\$12.46 million]
- 3a - Groundwater Extraction and Air Stripping with Offsite Disposal to Surface Water [\$64.73 million]
- 3b - Groundwater Extraction and Air Stripping with Offsite Discharge for Reuse [\$24.69 million]

The costs provided above are only screening level and will change based on the detailed analysis in the next section.

Table 4.3-1
Summary of Alternatives Screening Evaluation
SE Rockford Site
SE Rockford, Illinois

Alternative	Effectiveness	Implementability	Years to Implement	Estimated Cost (Million \$)	Screening Status
1. No Action	No reduction in M/T/V or potential risk of groundwater ingestion/dermal exposure. ARARs will not be met.	Long-term groundwater monitoring. Easy to implement.	0	1.35	Retained
2a. Use Restrictions	No reduction in M/T/V. Potential risk of groundwater ingestion/dermal exposure is reduced. ARARs are not expected to be met.	Long-term groundwater monitoring, public education to emphasize that the use of groundwater will be a danger to human health and expansion of public water system. Easy to implement.	200	3.79	Retained
2b. Limited Action and Natural Attenuation	Significant reduction in contaminant mobility. No significant reduction in toxicity or volume. Reduction of potential risk of groundwater ingestion/dermal exposure. ARARs are not expected to be met.	Modeling and design of extraction system required. Treatment system design and pilot-scale studies required. Permit requirements and discharge limits will need to be met prior to disposal of treated water. Pump-and-treat system may have difficulty in removing final low concentrations from aquifer.	200	12.46	Retained
3a. Groundwater Extraction and Air Stripping with Offsite Discharge to Surface Water	Significant and permanent reduction in contaminant M/T/V. Significant reduction of potential risk of groundwater ingestion/dermal exposure. ARARs are not expected to be met.	Modeling and design of extraction system required. Treatment system design and pilot-scale studies required. Permit requirements and discharge limits will need to be met prior to disposal of treated water. Pump-and-treat system may have difficulty in removing final low concentrations from aquifer.	125	64.73	Retained
3b. Groundwater Extraction and Air Stripping with Offsite Discharge to Reuse	Significant and permanent reduction in contaminant M/T/V. Significant reduction of potential risk of groundwater ingestion/dermal exposure. ARARs are not expected to be met.	Modeling and design of extraction system required. Treatment system design and pilot-scale studies required. Permit requirements and discharge limits will need to be met prior to disposal of treated water. Pump-and-treat system may have difficulty in removing final low concentrations from aquifer.	75	24.69	Retained



Section Five

Section 5

Detailed Analysis of Remedial Action Alternatives

5.1 Individual Analysis of Alternatives

This section of the Southeast Rockford feasibility study provides a detailed analysis of the remedial action alternatives retained from the screening process presented in Section 4. The retained remedial action alternatives include:

- Alternative 1 — No Action. Long-term monitoring.
- Alternative 2a — Use Restrictions, Connections to Utility System. Long-term monitoring.
- Alternative 2b — Limited Action, groundwater extraction and air stripping in a limited area coupled with natural attenuation of plume in less contaminated areas. Discharge offsite to surface water. Long-term monitoring.
- Alternative 3a — Groundwater extraction and air stripping at five locations across the site with offsite disposal to surface water. Long-term monitoring.
- Alternative 3b — Groundwater extraction and air stripping at five locations across the site with offsite discharge for reuse. Long-term monitoring.

It must be noted that control of source areas of contamination including NAPLs is a prerequisite for every alternative analyzed. Without source control, contamination will continue to be released and remediation times will increase as described in Appendix C. Therefore, the success of each of the alternatives analyzed in this section is contingent on remediation of contamination sources.

During the detailed analysis procedure, each of the above alternatives are evaluated according to nine CERCLA criteria. These criteria are as follows:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume
5. Short-term effectiveness
6. Implementability
7. Cost
8. Support agency acceptance
9. Community acceptance

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are categorized as threshold criteria which each alternative must meet (unless specific ARARs are waived) in order to be considered for selection.

Criteria 3 through 7 are the primary criteria upon which the detailed analysis of alternatives is based. The final two criteria, state and community acceptance, are evaluated during preparation of the ROD to be written by the State.

The first criterion, overall protection of human health and the environment, focuses on whether the alternative achieves adequate protection of human health and the environment and secondly how site risks posed through each pathway addressed by the Baseline Risk Assessment (BRA) are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. Any unacceptable short-term or cross-media impacts will also be considered at this time. Compliance with ARARs, criterion No. 2, is used to determine if each alternative will meet all Federal and State ARARs. ARARs have been previously discussed in the RI report and in Section 2. Tables 2.2-1 and 2.2-2 present ARARs identified for the Southeast Rockford Site.

The third criterion is long-term effectiveness and permanence. This evaluation criterion addresses the risk remaining at the Site after response objectives have been met. The primary focus of this evaluation are the extent and effectiveness of the controls to manage the risk represented by treatment residuals and for the remaining untreated waste. The evaluation is subdivided into two components: magnitude of residual risk and the adequacy and reliability of controls. The magnitude of residual risk assesses risk remaining from untreated waste or treatment residuals at the conclusion of remedial actions. The adequacy and reliability of controls factor assesses the adequacy and suitability of controls used to manage treatment residuals or untreated wastes remaining at the Site.

The fourth criterion, reduction of toxicity, mobility, or volume through treatment, addresses the preference for the selection of a remedial technology that permanently and significantly reduces toxicity, mobility, or volume of the contamination. This preference is satisfied when treatment is used to reduce the principal threat at a site through destruction, reduction of total mass, irreversible reduction in mobility, or reduction of total volume of the contaminated media.

The fifth criterion, short-term effectiveness, addresses the effect of alternatives during the construction and implementation of remediation. The following factors will be addressed as appropriate for each alternative:

- Protection of the community during remedial action
- Protection of workers during remedial actions
- Environmental impacts
- Time until remedial response objectives are achieved

The sixth criterion, implementability, addresses the technical and administrative feasibility of various services and the availability of services and materials required during implementation of each alternative. Technical factors include: (1) construction and operation, (2) reliability of technology, (3) ease of undertaking additional remedial action, and (4) monitoring considerations such as the evaluation of risk of exposure as a consequence of insufficient monitoring to detect system failure. Administrative feasibility addresses activities required to coordinate with other offices and agencies (e.g., permits). An evaluation of the availability of services and materials will include: (1) adequacy of offsite treatment or storage capacity and disposal services; (2)

availability of necessary equipment and specialists and provisions to ensure any necessary additional services, (3) availability of services and materials plus the potential for obtaining complete and competitive bids, and (4) availability of prospective technologies.

The seventh evaluation criterion is the cost of each alternative. Cost procedures follow the guidelines outlined in the Remedial Action Costing Procedures Manual (EPA 1985). Cost for each remedial action alternatives includes capital (indirect and direct) and annual O&M costs. Expenditures for labor, equipment, and materials are examples of direct costs, while engineering, financial, and legal services are examples of indirect costs. Annual O&M costs are associated with post-construction activities necessary to ensure the continued effectiveness of a remedial action. Details of cost estimation are provided in Appendix B. The accuracy of the cost estimates is within +50 percent and -30 percent. Present worth costs are based on 5 percent interest for the estimated cleanup period (ranging from 75 to 205 years).

The estimate of cleanup times is crucial to the calculation of the cost of each alternative. The methodology for cleanup time estimation is fully described in Appendix C of the FS, however a synopsis is presented in this section.

Groundwater flow and contaminant transport were simulated using *DYNFLOW*TM and *DYNTRACK*TM, CDM's proprietary computer models. The models have been peer-reviewed and have been successfully applied at numerous hazardous waste sites across the nation. The models were used to simulate the distribution of contaminants for each of the alternatives evaluated, including contribution by advection, diffusion, and retardation under equilibrium conditions. However, non-equilibrium processes are extremely important in predicting desorption and aquifer cleanup times.

The final evaluation criteria, state and community acceptance, will be addressed in the ROD once comments from the RI/FS report and proposed remedial plan have been received.

5.2 Alternative 1 - No Action

The No Action alternative is required by the CERCLA guidelines to serve as a baseline case for comparison with the other remedial alternatives. This alternative consists of the installation of four pairs of groundwater monitoring wells along Rock River and one well upgradient of the residential area not targeted for connection to the Utility System and the long-term quarterly groundwater monitoring of the new wells and 25 existing wells across the Site over 205 years.

Overall Evaluation of Cleanup Times

As discussed in Section 4 of the RI report, PCE, TCA, TCE, DCA, and DCE undergo natural anaerobic biodegradation in most aquifers. The rate of this degradation is difficult to predict accurately. Using rates calculated from data collected at the Southeast Rockford site, TCA should degrade to concentrations less than the 200 µg/L MCL in about 205 years assuming that there are no continuing contaminant sources. However, additional time will be necessary for the DCE and VC that is produced to degrade.

Protection of Human Health and the Environment

This alternative is not protective of human health or the environment as it does not address unacceptable current and potential risk to human health. Alternative 1 — No Action is, therefore, not considered to be protective of human health and the environment.

Compliance with ARARs

After an extended period of time, (at least 205 years assuming source control) this alternative will achieve the remedial action objectives or ARARs established for the Site.

Reduction in Toxicity, Mobility, or Volume

No reduction in contaminant toxicity, mobility or volume is realized and groundwater ARARs would be exceeded.

Long-Term Effectiveness

The magnitude of residual risk associated with this alternative will remain high. The control to be implemented includes only monitoring. This will allow determination of continued exposure to human health and the environment, but will not prevent such exposure.

Short-Term Effectiveness

Since no further remedial actions would be implemented at the Site, this alternative cannot be considered to possess any short-term effectiveness. It is assumed that Level D personal protection would be used, with Level C as a contingency, when sampling the wells for groundwater monitoring purposes.

Implementability

The implementability criteria, the availability of services and equipment, and the ability to construct and operate, apply only to the monitoring activities associated with this alternative. Therefore, this alternative could be implemented immediately.

Additional remedial actions, if required, could be implemented at a future date on the basis of monitoring results. Essentially, this approach consists of allowing exposure to be detected by monitoring and then potentially responding to prevent further exposure. Therefore, it is unreliable in protection of human health and the environment.

Cost

The costs associated with implementation of Alternative 1 consists of groundwater monitoring well installation and quarterly sampling for 205 years. These costs are detailed in Appendix B and are summarized below.

Capital Cost	\$34,000
Annual O&M Cost	\$55,000
Present Worth Cost (at 5 percent for 205 years)	\$1,124,000

5.3 Alternative 2a - Use Restrictions

This alternative includes institutional controls to restrict the potable use of contaminated groundwater in conjunction with long-term groundwater monitoring. The groundwater

monitoring program consists of quarterly monitoring for VOCs at 25 existing monitoring wells and nine groundwater monitoring wells to be installed at five locations. Included in the institutional controls is a public education program to discourage the use of groundwater for drinking and bathing. Public education will be implemented through the use of fact sheets included in utility billings, public meetings, and local news media announcements. The restrictions on the potable use of groundwater wells would be implemented by expanding existing water utility mains to service all neighborhoods within the site. As discussed in Section 4, there is no mechanism to compel connection to the Utility System regardless of the human health impact.

Overall Evaluation of Cleanup Times

The time to reduce concentrations to acceptable levels is identical to the period discussed in Alternative 1. The discussion and times are the same for this alternative. More than 205 years would be required to reduce concentrations to MCLs.

Protection of Human Health and the Environment

Assuming that all potentially impacted residents connect to the Utility System, this alternative is protective of human health. Modeling results summarized in Appendix C indicate that the environmental receptor (the Rock River) is not impacted by concentrations of contaminants above the Ambient Water Quality Criteria. Therefore, no risk to the environment is known.

Compliance with ARARs

After an extended period of time, (at least 205 years) this alternative will achieve the remedial action objectives or ARARs established for the Site as provided for by CERCLA would be required.

Reduction in Toxicity, Mobility, or Volume

No reduction in contaminant toxicity, mobility or volume is realized and groundwater ARARs would be exceeded.

Long-Term Effectiveness

The magnitude of residual risk associated with this alternative is lower than Alternative 1. The controls to be implemented include public education, use restrictions, and monitoring. This will help prevent human exposure by ingestion, inhalation, or dermal contact, but will not protect the environment.

Short-Term Effectiveness

Since no further remedial actions would be implemented at the Site, this alternative poses no additional short-term risks to on site workers, other than risks that presently exist. It is assumed that Level D personal protection would be used, with Level C as a contingency, when sampling the wells for groundwater monitoring purposes.

Implementability

The implementability criteria, the availability of services and equipment and the ability to construct and operate, apply to the use restrictions, public education, and monitoring activities associated with this alternative. The public education and monitoring programs could be

implemented quickly. The use restrictions may be more difficult to implement, could take a year or more, and would require cooperation among the state, county, and city agencies.

Additional remedial actions, if required, could be implemented at a future date on the basis of monitoring results.

Cost

The costs associated with the implementation of the alternative include the groundwater monitoring wells (nine new wells and 25 existing wells), installation of the new wells, and quarterly sampling for 205 years as described for Alternative 1, installation of over four miles of potable water mains, plus costs associated with a public information program. A detail of the costs are provided in Appendix B and are summarized below.

Capital Cost	\$2,016,000
Annual O&M Cost	\$65,000
Total Present Worth Cost (at 5 percent for 205 years)	\$3,314,000

5.4 Alternative 2b — Limited Action and Natural Attenuation

The required extraction wells and design pumping rates for this alternative are summarized below. In addition to the items described below, this alternative also includes all aspects of Alternatives 1 and 2a. An air stripper is included for the pumping network. Off-gas treatment will not be required for this alternative. Costs include the monthly sampling of the extraction wells and monthly sampling for permit compliance monitoring at the treated effluent discharge location. Also included in the alternative description is treatment time and estimated concentration for each contaminant of concern. Pumping Network PW4 on Figure 4.2-1 is a representation of the pumping network for this alternative. Details are presented below:

Four wells rated at 250 gpm/well (1,000 gpm total) located along 17th Street between Harrison Avenue and Reed Avenue. Well spacing is 400 feet. Table 5.4-1 summarizes the estimated concentrations of contaminants of concern and the network design. The removal of TCE is the limiting factor in air stripper design. Vapor phase GAC adsorption is not expected to be required for the treatment system. Treated effluent discharge that was investigated for this alternative was offsite disposal to surface water.

Coupled with the limited pumping network, natural attenuation will be responsible for restoration of areas of lower contamination with the plumes.

Overall Evaluation of Cleanup Times

Appendix C present the results of modeling to evaluate cleanup time. A summary of these evaluations follow. Modeling simulations for this alternative indicate that pumping for a period of 75 to 125 years at PW4 combined with natural attenuation will result in contaminant concentrations below the MCL (200 µg/L) for TCA.

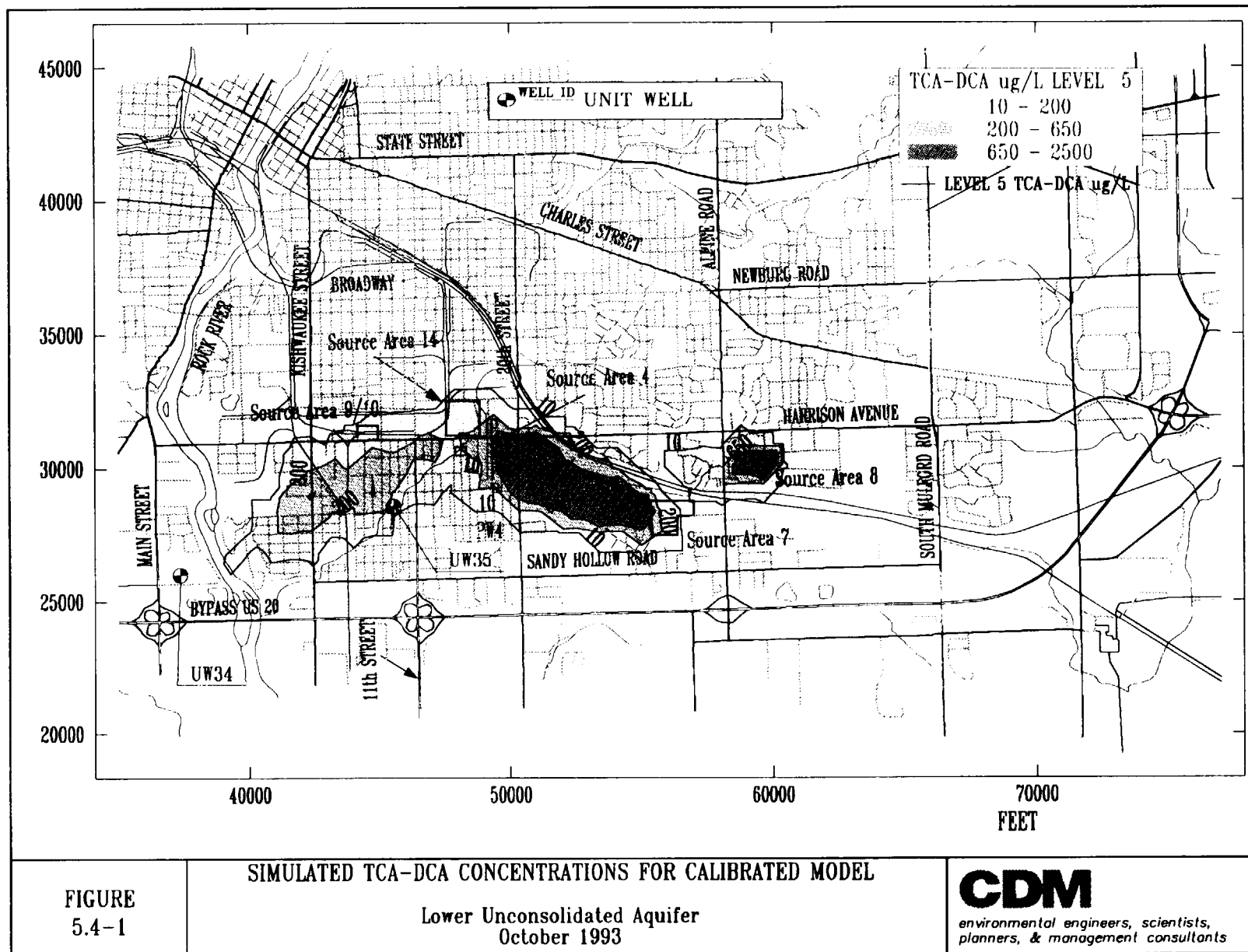
This system would be effective in containing the plume to its present location. The current plume as simulated by the groundwater model is shown in Figure 5.

Table 5.4-1
Well Network Design and Maximum Inflow Contaminant Concentration for PW4

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
161	769.45	99.09	185.24	86.16	250	0.0
197	757.93	61.45	153.64	92.18	250	790.6
234	750.75	113.06	183.39	70.33	250	791.2
273	750.00	112.50	181.24	68.74	250	790.7
Total					1,000	

Inflow Concentration (µg/L)

Vinyl chloride	1
Dichloromethane	1
1,1-Dichloroethene	33
1,1-Dichloroethane	92
1,2-dichloroethene	110
1,1,1-Trichloroethane	1
1,2-Dichloroethane	140
1,2-Dichloropropane	1
Trichloroethene	56
1,1,2-Trichloroethane	1
Tetrachloroethene	1
Benzene	2
Toluene	41
Ethylbenzene	3
Xylene	15



Protection of Human Health and the Environment

A reduction in the future risk of groundwater ingestion, inhalation, and dermal contact would be achieved through this alternative since contaminated groundwater is being contained and extracted, as long as the groundwater extraction system is in operation. If contaminated groundwater upgradient from the plume is extracted and treated to levels below MCLs, a reduction in the potential risk of groundwater ingestion, inhalation, and dermal contact would be achieved.

Compliance with ARARs

The extraction scenario removes only a portion of the groundwater with contaminant concentrations in excess of MCLs, the remainder of the plume is remediated by way of natural attenuation. ARARs are met after a period of between 75 and 125 years. Over the length of the remedial action, risk will be reduced gradually, and human health will be protected by supply of an alternate water supply until ARARs are achieved. The treated water would meet all surface water discharge requirements prior to discharge to the surface water.

Long-Term Effectiveness

The potential of further contaminant migration via groundwater would not be eliminated until remediation is complete, although this alternative captures a significant volume of contaminated water. The groundwater treatment system would require performance specifications to ensure the adequate operation of the system. Long-term public health threats associated with groundwater ingestion, inhalation, and dermal contact would also be reduced.

Reduction in Toxicity, Mobility, or Volume

This alternative captures a portion of contamination. It therefore represents a reduction in mobility, toxicity, and volume of contamination in the area where human health is most likely to be affected, and eventual elimination of the remainder of the plume by natural attenuation.

Short-Term Effectiveness

Small-scale construction activities during installation of the extraction wells and during treatment system operation may result in the release of minimal volatilized contaminants, and the operation of drilling equipment would produce additional noise. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in these specific areas and the use of personal protection equipment by all personnel at the Site. It is assumed that Level D personal protection, with Level C as a contingency, would be used. Equipment and personnel decontamination facilities would also be necessary.

Implementability

Preliminary Schedule

Approximately six months would be required for design and contractor selection. The implementation of the groundwater extraction and treatment systems would require approximately one year, and the actual groundwater extraction and remediation would require approximately 125 years. This is contingent upon the effectiveness of the extraction and treatment systems and includes no shut-downs or major problems.

Engineering Considerations for Groundwater Extraction and Discharge

The major engineering considerations to implement the limited action alternative including groundwater extraction and discharge systems are listed below.

The surface water discharge option would require testing of existing storm sewer conveyance systems.

- Design, installation, and testing of extraction well system
- Potential for well plugging (reduction in flows) over time
- Monitoring requirements
- Cleanup verification
- Well abandonment

Engineering Considerations for Groundwater Treatment

The major engineering considerations to implement the groundwater treatment system include:

- Design flow and water quality
- Siting and design of air stripper
- Monitoring the influent and effluent water quality
- Process effectiveness monitoring
- Potential for fouling of media

Site security is considered to be a component of institutional and site access controls.

Equipment and Materials

The major system components anticipated for operation under this alternative include:

- Four submersible groundwater pumps
- One air stripping tower (with packing) for the groundwater treatment system
- Piping, fittings, and valves for fluids transport
- Electrical conduit and wiring for electric power and sensors
- System instrumentation and controls
- Storage tanks

The major construction equipment and materials required to implement this alternative include:

- Contractor's temporary facilities and utilities
- Well drilling equipment
- Front-end loader
- Backhoe

Operation and Maintenance

Long-term groundwater monitoring for cleanup verification purposes and to track contaminant plume migration would be required for this alternative. In addition to the monitoring wells previously described, it is assumed that the four extraction wells would be sampled and water levels recorded on a monthly basis. All samples would be collected and analyzed for the VOCs of concern.

The groundwater treatment system would also require monitoring and maintenance during its approximate 125-year operational life. Monitoring of the treatment system would include periodic sampling of the influent and effluent from the treatment system and analysis in accordance with surface water discharge permit requirements. Sample collection is assumed to be on a monthly basis at one location.

Maintenance of the extraction and treatment systems would be performed in accordance with O&M requirements developed after equipment specification and procurement are completed. At a minimum, it is expected that regular periodic maintenance and replacement would be required on the submersible pumps, valves, and fittings of fluids piping systems, as well as on the treatment system to ensure the efficient operation of the system.

Cost

The costs for this alternative include the costs described in Section 5.3 plus the pump and treat system. A detail of the costs are provided in Appendix B and are summarized below.

Capital Cost	\$3,002,000
Annual O&M Cost	\$351,000
Total Present Worth Cost (at 5 percent for 125 years)	\$10,021,000

5.5 Alternatives 3a and 3b — Groundwater Extraction and Air Stripping with Offsite Discharge to Surface Water, or Offsite Discharge for Potable Reuse

Alternatives 3a and 3b were designed to restore the entire aquifer to MCLs within the area of concern. The required extraction wells and design pumping rates for these alternatives are summarized below.

In addition to the items described below, these alternatives also includes all aspects of Alternatives 1 and 2a. An air stripper is included at each pump network. Off-gas treatment will be required at location PW3A for these alternatives. Costs include monthly sampling of the extraction wells and monthly sampling for permit compliance monitoring at six treated effluent discharge locations. Also included in the alternatives description are estimated treatment time and estimated concentration for each contaminant of concern. Figure 4.2-1 is a representation of the alternatives configuration. Details are presented below:

Location PW1: Four wells rated at 333 gpm/well (1,332 gpm total) located approximately 1,000-foot east of Rock River and to the north of Sandy Hollow Road. Well spacing is 1,000 feet. The estimated concentrations of contaminants of concern and the network design are provided in Table 5.5-1. The removal of TCE is the limiting factor in air stripper design. Off-gas control is not expected to be required for the PW1 treatment system.

Location PW2: Five wells rated at 333 gpm/well (1,665 gpm total) located at Harrison Avenue and 5th Street running southeast to Brooke Road and 8th Street. Well spacing is 800 feet. The estimated concentrations of contaminants of concern and the network design are provided in

Table 5.5-1
Well Network Design and Maximum Inflow Contaminant Concentration for PW1

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1116	690.33	30.09	90.25	60.17	333	0.0
113	691.00	30.25	90.75	60.50	333	649.5
1119	690.84	30.21	90.63	60.42	333	1,249.3
35	690.44	30.11	90.33	60.22	333	519.6
Total					1,332	

Inflow Concentration (µg/L)

Vinyl chloride	1
Dichloromethane	1
1,1-Dichloroethene	13
1,1-Dichloroethane	17
1,2-dichloroethene	23
1,1,1-Trichloroethane	1
1,2-Dichloroethane	50
1,2-Dichloropropane	1
Trichloroethene	75
1,1,2-Trichloroethane	1
Tetrachloroethene	1
Benzene	1
Toluene	1
Ethylbenzene	1
Xylene	1

Table 5.5-2. The removal of 1,1,2-TCA is the limiting factor in air stripper design. Off-gas control is not expected to be required for the PW2 treatment system.

Location PW3A: Two wells rated at 250 gpm/well (500 gpm total) located at Harrison Avenue and Kinsey Street running southeast to Alton Avenue and Hanson Street. Well spacing is 800 feet. The estimated concentrations of contaminants of concern and the network design are provided in Table 5.5-3. The removal of benzene is the limiting factor in air stripper design. Because of the high loading of BETX from PW3A, vapor phase GAC adsorption will be required for stripper off-gas treatment. The spent carbon will be shipped off-site for regeneration. The material will be manifested and transported to an approved regeneration facility according to RCRA requirements.

Location PW3B: Two wells rated at 250 gpm/well (500 gpm total) located at Wills Avenue and Hanson Street running southeast to Reed Avenue and Potter Street. Well spacing is 800 feet. The estimated concentrations of contaminants of concern and the network design are provided in Table 5.5-4. The removal of TCE is the limiting factor in air stripper design. Off-gas control is not expected to be required for the PW3B treatment system.

Location PW5: Four wells rated at 250 gpm/well (1,000 gpm total) located near Alton Avenue and 21st Street running south near Reed Avenue and 21st Street. Well spacing is at 400 feet. The estimated concentrations of contaminants of concern and the network design are provided in Table 5.5-6. The removal of 1,1,2-TCA is the limiting factor in air stripper design. Off-gas control is not expected to be required for the PW5 treatment system.

Location PW6: Five wells rated at 70 gpm/well (350 gpm total) located east of Balsam Lane, starting near the railroad tracks and running south to the area at the east end of Balsam Lane. Well spacing is 400 feet. The estimated concentrations of contaminants of concern and the network design are provided in Table 5.5-6. The removal of 1,1,2-TCA is the limiting factor in air stripper design. Off-gas control is not expected to be required for the PW6 treatment system.

Total extraction rate is 5,347 gpm using 22 wells.

Overall Evaluation of Cleanup Times

Appendix C present the results of modeling to evaluate cleanup time. A summary of these evaluations follows. Contaminant transport simulations for this alternative indicate that between 25 and 75 years of pumping at a rate exceeding 5,000 gpm is needed to remediate the entire groundwater plume to the MCL for TCA (200 µg/L).

This system would be the most effective in remediating the Site as a whole to MCLs. Based on 1,1,1-TCA, cleanup times are estimated to range from 25 to 75 years using this alternative. However, cleanup times may be longer for more persistent compounds such as PCE and TCE to reach their MCLs.

Table 5.5-2
Well Network Design and Maximum Inflow Contaminant Concentration for PW2

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1114	727.37	37.77	113.30	75.53	333	0.0
226	732.13	39.72	119.17	79.45	333	667.2
190	736.65	41.60	124.81	83.20	333	705.6
134	739.06	43.05	129.14	86.09	333	894.5
119	743.52	43.38	130.14	86.76	333	1,133.3
Total					1,665	

Inflow Concentration (µg/L)

Vinyl chloride	1
Dichloromethane	1
1,1-Dichloroethene	410
1,1-Dichloroethane	150
1,2-dichloroethene	1
1,1,1-Trichloroethane	1
1,2-Dichloroethane	1,400
1,2-Dichloropropane	1
Trichloroethene	140
1,1,2-Trichloroethane	60
Tetrachloroethene	50
Benzene	1
Toluene	420
Ethylbenzene	19
Xylene	77

Table 5.5-3
Well Network Design and Maximum Inflow Contaminant Concentration for PW3A

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1113	749.76	44.81	134.43	89.62	250	0.0
231	749.95	45.51	136.52	91.01	250	585.5
Total					500	

Inflow Concentration (µg/L)

Vinyl chloride	1
Dichloromethane	1
1,1-Dichloroethene	9
1,1-Dichloroethane	58
1,2-dichloroethene	34
1,1,1-Trichloroethane	1
1,2-Dichloroethane	38
1,2-Dichloropropane	1
Trichloroethene	5
1,1,2-Trichloroethane	1
Tetrachloroethene	1
Benzene	20,000
Toluene	310,000
Ethylbenzene	20,000
Xylene	20,000

Table 5.5-4
Well Network Design and Maximum Inflow Contaminant Concentration for PW3B

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1112	750.00	44.24	132.70	88.47	250	010
159	750.92	40.51	121.53	81.02	250	887.1
Total					500	

Inflow Concentration (µg/L)

Vinyl chloride	1
Dichloromethane	1
1,1-Dichloroethene	23.5
1,1-Dichloroethane	60
1,2-dichloroethene	30.5
1,1,1-Trichloroethane	1
1,2-Dichloroethane	165
1,2-Dichloropropane	1
Trichloroethene	50.5
1,1,2-Trichloroethane	1
Tetrachloroethene	1.5
Benzene	12
Toluene	12
Ethylbenzene	12
Xylene	12

Table 5.5-5
Well Network Design and Maximum Inflow Contaminant Concentration for PW5

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1111	763.37	105.60	185.84	80.23	250	0.0
1110	767.22	91.32	178.81	87.49	250	587.0
1109	775.87	84.20	178.72	94.52	250	476.8
1108	786.52	79.05	180.88	101.82	250	609.5
Total					1,000	

Inflow Concentration (µg/L)

Vinyl chloride	5
Dichloromethane	50
1,1-Dichloroethene	59
1,1-Dichloroethane	150
1,2-dichloroethene	190
1,1,1-Trichloroethane	50
1,2-Dichloroethane	650
1,2-Dichloropropane	50
Trichloroethene	190
1,1,2-Trichloroethane	100
Tetrachloroethene	84
Benzene	25
Toluene	25
Ethylbenzene	25
Xylene	25

Table 5.5-6
Well Network Design and Maximum Inflow Contaminant Concentration for PW6

Well Node	Model Ground Elev. (ft)	Pumping Depth (ft. bgl)			Pumping Rate (gpm)	Horizontal Dist. from Previous Node (ft.)
		Top	Base	Interval		
1104	810.0	98.04	203.81	105.77	70	0.0
1105	810.0	119.21	216.71	97.50	70	363.7
1106	810.0	81.01	191.64	110.63	70	455.9
1107	810.0	64.68	184.68	120.00	70	425.8
1103	810.0	57.83	180.84	123.01	70	453.3
Total					350	

Inflow Concentration (µg/L)

Vinyl chloride	22.6
Dichloromethane	18.4
1,1-Dichloroethene	138.2
1,1-Dichloroethane	188
1,2-dichloroethene	2,674.4
1,1,1-Trichloroethane	152.4
1,2-Dichloroethane	3,396
1,2-Dichloropropane	146.8
Trichloroethene	187.6
1,1,2-Trichloroethane	146.8
Tetrachloroethene	156.8
Benzene	140.8
Toluene	170.8
Ethylbenzene	178.8
Xylene	356.8

Protection of Human Health and the Environment

A reduction in the potential risk of groundwater ingestion, inhalation, and dermal contact would be achieved through this alternative since contaminated groundwater is being extracted, as long as the groundwater extraction system is in operation. A permanent reduction in the potential risk of groundwater ingestion, inhalation, and dermal contact will be achieved after the period of remediation (25 to 75 years).

Compliance with ARARs

This extraction scenario removes all groundwater with contaminant concentrations in excess of MCLs. However compliance with ARARs is not anticipated for 75 years. The volume of water to be remediated is approximately 235 billion gallons. Depending on the offsite discharge option, the treated water would meet: all surface water discharge requirements prior to discharge to the surface water, or all drinking water standards.

Long-Term Effectiveness

The potential of further contaminant migration via groundwater would not be entirely eliminated although these alternatives capture the largest volume of contaminated water. The groundwater treatment system would require performance specifications to ensure the adequate operation of the system. Long-term public health threats associated with groundwater ingestion, inhalation, and dermal contact would also be reduced.

Reduction in Toxicity, Mobility, or Volume

These alternatives restore the aquifer to MCLs in the shortest time frame of all of the evaluated alternatives. After a period of approximately 75 years the mobility, toxicity, and volume of contamination have been reduced to a level consistent with ARARs.

Short-Term Effectiveness

Small-scale construction activities during installation of the extraction wells and during treatment system operation may result in the release of minimal volatilized contaminants, and the operation of drilling equipment would produce additional noise. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in these specific areas and the use of personal protection equipment by all personnel at the Site. It is assumed that Level D personal protection, with Level C as a contingency, would be used. Equipment and personnel decontamination facilities would also be necessary.

Implementability

Preliminary Schedule

Approximately one year would be required for design and contractor selection. The implementation of the groundwater extraction and treatment systems would require approximately one year, and the actual groundwater extraction and remediation would require in excess of 75 years. This is contingent upon the effectiveness of the extraction and treatment systems and includes no shut-downs or major problems.

Engineering Considerations for Groundwater Extraction and Discharge

The major engineering considerations to implement the groundwater extraction and discharge systems were discussed previously in Section 5.4. The potable reuse option would require the design, installation, and testing of finished water booster stations.

Engineering Considerations for Groundwater Treatment

The major engineering considerations to implement the groundwater treatment system were discussed previously in Section 5.4.

Equipment and Materials

The major system components anticipated for operation under this alternative include:

- Twenty-two submersible groundwater pumps
- Six air stripping towers (with packing and off-gas treatment as required) for the groundwater treatment system
- Piping, fittings, and valves for fluids transport
- Electrical conduit and wiring for electric power and sensors
- System instrumentation and controls
- Storage tanks
- Booster pump stations

The major construction equipment and materials required to implement this alternative were discussed previously in Section 5.4.

Operation and Maintenance

Long-term groundwater monitoring for cleanup verification purposes and to track contaminant plume migration would be required for these alternatives. It is assumed that the 22 wells would be sampled and water levels recorded on a monthly basis. All samples would be collected and analyzed for the VOCs of concern.

The groundwater treatment system would also require monitoring and maintenance during its approximate 75-year operational life. Monitoring of the treatment system would include periodic sampling of the effluent from the treatment system and analysis in accordance with the potable water supply, or surface water discharge permit requirements. Sample collection is assumed to be on a monthly basis at five locations.

Maintenance of the extraction and treatment systems would be performed in accordance with O&M requirements developed after equipment specification and procurement are completed. At a minimum, it is expected that regular periodic maintenance and replacement would be required on the submersible pumps, valves, and fittings of fluids piping systems, as well as on the

treatment system to ensure the efficient operation of the system. The spent GAC from off-gas control is regenerated onsite. The capital and O&M costs for steam regeneration have been factored into the cost estimates.

Cost

The costs for these alternatives include the costs described in Section 5.3 plus the pump and treat systems. A detail of the costs are provided in Appendix B and are summarized below.

Alternative 3a — Groundwater Extraction and Air Stripping with Offsite Disposal (Surface Water)

Capital Cost	\$8,276,000
Annual O&M Cost	\$2,174,000
Total Present Worth (at 5 percent for 75 years)	\$50,723,000

Alternative 3b — Groundwater Extraction and Air Stripping with Offsite Discharge (Potable)

Capital Cost	\$14,314,000
Annual O&M Cost	\$310,000
Total Present Worth (at 5 percent for 75 years)	\$20,362

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Section 6



Section Six

Section 6

Comparison and Summary of Alternatives

This section compares and summarizes the effectiveness of each interim remedial action alternative. In order for a specific alternative to be selected for remediation of the Southeast Rockford Site, three main criteria must be met: the threshold criteria (overall protectiveness and attempted compliance with ARARs), the primary balancing criteria (long-term effectiveness, reduction of mobility, toxicity, and volume through treatment, short-term effectiveness, implementability, and cost), and the modifying criteria (state and community acceptance). This section summarizes the evaluation of each alternative based on the threshold and primary balancing criteria. The modifying criteria, which include state and community acceptance, would be evaluated by EPA and IEPA prior to final selection of a remedy.

6.1 Threshold Criteria

Overall protection of human health and the environment and attempted compliance with ARARs are threshold requirements that each alternative must meet in order to be eligible for selection. A summary of this evaluation is presented in Table 6.1-1.

6.1.1 Overall Protectiveness

Each alternative was evaluated to determine whether it is likely to effectively mitigate and minimize the long-term risk of harm to public health and the environment currently presented at the Site. For the purposes of this presentation, potential risk to human health and the environment is "eliminated" for Alternative 3a and 3b with a 75-year remediation time. Alternatives 2a and 2b are both protective of human health due to the institutional control component. Alternative 2a is not protective of the environment in that no active restoration of the aquifer is performed. Alternative 2b is protective of the environment in that the aquifer is restored after 125 years.

6.1.2 Compliance with ARARs

A goal of Superfund remedial activities under SARA is to attain ARARs of federal, state, or local environmental statutes, whichever are more stringent. Each remedial alternative was evaluated with regard to its ability to comply with the ARARs, which are generally based on acceptable levels of contamination to preserve the environment, public health, and welfare. ARARs for the Site were previously presented in Section 2. For the Southeast Rockford Site, ARARs are expected to be met for Alternatives 2b, 3a, and 3b.

6.2 Primary Balancing Criteria

The five primary balancing criteria are long-term effectiveness and permanence, reduction of mobility, toxicity, and volume through treatment, short-term effectiveness, implementability, and cost. These are presented in Table 6.2-1 and are discussed below.

6.2.1 Long-Term Effectiveness and Permanence

These two aspects of remedial actions determine their desirability on the basis of effectiveness and effective life. Effectiveness refers to the degree to which an action will meet the Site

Table 6.1-1
Summary of the Public Health and Environmental Effects Evaluation
SE Rockford Site
City of SE Rockford, Illinois

Remedial Alternative	Overall Protectiveness	Compliance with ARARs
1. No Action	Does not eliminate any exposure pathways or reduce the level of risk	ARARs are not met
2a. Use Restrictions	Reduces potential risk of groundwater ingestion/dermal/inhalation exposure through public education, and water utility system expansion	ARARs are not met
2b. Limited Action	Greatly reduces potential risk of groundwater ingestion/dermal/inhalation	ARARs are met
3a. Groundwater Extraction and Air Stripping with Offsite Disposal to Surface Water	Eliminates potential risk of groundwater ingestion/dermal/inhalation	ARARs are met
3b. Groundwater Extraction and Air Stripping with Offsite Discharge for Reuse	Eliminates potential risk of groundwater ingestion/dermal/inhalation	ARARs are met

Table 6.2-1
Summary of Alternatives Evaluation
SE Rockford Site
City of SE Rockford, Illinois

Remedial Alternative	Long-Term Effectiveness and Permanence	Reduction of M/T/V* through Treatment	Short-Term Effectiveness	Implementability		Cost (million \$)
				Technical/Engineering Considerations	Estimated Time for Implementation (Years)	Total Present Worth
1. No Action	Does not limit migration of or remove contaminants. Does not eliminate any exposure pathways or reduce level of risk. ARARs are not met.	No reduction of M/T/V	Level D protective equipment would be required during groundwater sample collection	None	155 - 205	1.1
2a. Use Restrictions	Does not limit migration of or remove contaminants, but will reduce potential risk of groundwater inhalation/ ingestion/ dermal exposure. ARARs are not met.	No reduction of M/T/V	Level D protective equipment would be required during groundwater sample collection.	None	155 -205	3.3
2b. Limited Action	Pathway exposure is reduced. Reduces contamination and potential for further migration. ARARs are expected to be met.	Reduces contaminant M/T/V. Permanent remedy when coupled with natural attenuation of remaining contamination.	Level D protective equipment would be required during groundwater sample collection. Drilling activities may result in the potential release of a minimal amount of volatile organics and dust.	Treatment and system design. NPDES or reuse permit required. Operator error or system failure could result in release of contaminated water. Pump-and-treat systems have difficulty removing final low concentrations from aquifer.	75 - 125	10.0
3a. Groundwater Extraction and Air Stripping with Offsite Disposal to Surface Water	Pathway exposure is significantly reduced. Reduces contamination and potential for further migration. ARARs are expected to be met	Significant reduction of M/T/V. Permanent remedy after remediation is complete.	Level D protective equipment would be required during groundwater sample collection. Drilling activities may result in a potential release of a minimal amount of volatile organics and dust.	Treatment and system design. NPDES permit required. Operator error or system failure could result in release of contaminated water. Pump-and-treat systems have difficulty removing final low aquifer concentrations.	25 - 75	50.7

Table 6.2-1 (Continued)
Summary of Alternatives Evaluation
SE Rockford Site
City of SE Rockford, Illinois

Remedial Alternative	Long-Term Effectiveness and Permanence	Reduction of M/T/V* through Treatment	Short-Term Effectiveness	Implementability		Cost (million \$)
				Technical/Engineering Considerations	Estimated Time for Implementation (Years)	Total Present Worth
3b. Groundwater Extraction and Air Stripping with Offsite Discharge for Reuse	Pathway exposure is significantly reduced. Reduces contamination and potential for further migration. ARARs are expected to be met	Significant reduction of M/T/V. Permanent remedy after remediation is complete.	Level D protective equipment would be required during groundwater sample collection. Drilling activities may result in the potential release of a minimal amount of volatile organics and dust.	Treatment system design, Reuse permit required. Operator error or system failure could result in release of contaminated water. Pump-and-treat systems have difficulty removing final low concentrations from aquifer.	25 -75	20.4

* Mobility/Toxicity/Volume

remedial action goals and objectives, which were derived to minimize risk to public health and the environment. For this FS, exposure is "significantly reduced" for Alternative 3a and 3b, and "reduced" for Alternative 2b. The time to achieve cleanup goals is presented in Table 6.2-1. The effective life is the length of time this level of effectiveness can be maintained. The long-term effectiveness and permanence factors associated with each alternative are summarized in Table 6.2-1.

6.2.2 Reduction of M/T/V through Treatment

The degree to which the remedial action alternative reduces the mobility, toxicity, and/or volume of contamination is a second factor used to determine its desirability. An evaluation of each alternative on the basis of M/T/V reduction is also presented in Table 6.2-1. Only Alternatives 3a and 3b directly extract and treat the entire volume (approximately 235 billion gallons) of contaminated water. Alternative 2b directly extracts and treats approximately 20 percent of the volume of contaminated water (47 billion gallons). The remaining alternatives do not extract and treat any of the contaminated water. For this presentation, M/T/V is "significantly reduced" for Alternatives 3a and 3b, M/T/V is "reduced" for Alternative 2b. For the remaining alternatives, M/T/V is "not reduced."

6.2.3 Short-Term Effectiveness

Each alternative was examined to determine whether the alternative itself or its implementation would present any significant risks to public health or the environment. This evaluation generally involves short-term risks that would occur only while the alternative is being implemented. Additional possible risks include airborne releases of pollutants. The short-term effectiveness evaluation of each alternative is summarized in Table 6.2-1.

6.2.4 Implementability

For each alternative, constraints to implementation, such as difficult engineering requirements, the availability of equipment or offsite facilities, and permit and treatability/pilot study requirements, are considered. Also evaluated under this category are the labor and time requirements to attain the desired results should the alternative be implemented. These considerations are summarized in Table 6.2-1.

6.2.5 Cost Evaluation

Present Worth Analysis

The present worth of each alternative provides the basis for the cost comparison. The present worth cost represents the amount of money that, if invested in the initial year of the remedial action at a given rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life.

The present worth analysis was performed on all remedial alternatives using a 5 percent discount (interest) rate over periods ranging from 75 to 205 years, dependent of the alternative. Inflation and depreciation were not considered in preparing the present worth costs. The present worth costs for the remedial action alternatives are summarized in Table 6.2-1. Appendix B contains spreadsheets showing each component of the present worth costs summarized in Table 6.2-1.

6.3 Summary

A detailed evaluation of the remedial action alternatives in terms of non-cost and cost criteria was described in Section 5. A summary of this evaluation is presented in Table 6.2-1 to concisely show the major differences among the remedial action alternatives with regard to the criteria used: technical effectiveness and implementability, environmental and public health risk, institutional requirements, and costs.

Appendices

Appendix A

Appendix A
Record of Decision Summary Tables

Table A-1
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Years 1986-1989

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
6	Geneva Industries, TX 09/18/86 1st - Final	GW and soil contaminated with VOCs including TCE, and organics including PAHs and PCBs.	22,500 yd ³	Excavation and offsite disposal of contaminated soil and drums; capping; and GW pump and treatment using carbon adsorption with discharge to adjacent flood control channel.	Soil will be excavated to PCBs 100 mg/kg. GW will be treated to below TCE 1 µg/L.	\$14,990,000 (capital) \$532,000 (annual O&M) (years 1-2) \$483,000 (annual O&M) (years 3-30)
6	Highlands Acid Pit, TX 06/26/87 2nd - Final	Possible contamination of SW and GW with VOCs and metals.	Not applicable	No further action with SW and GW monitoring.	Contaminant concentration levels meet WQC and MCL requirements.	\$4,700 (capital) \$11,120 (annual O&M) (year 1) \$6,980 (annual O&M) (years 2-30)
6	Sheridan Disposal Services, TX Former Hazardous and Solid Waste Disposal Facility 09/27/89 2nd	GW contaminated VOCs including benzene, PCE, and TCE; and metals including arsenic.	Not specified	Natural attenuation with GW and SW monitoring; implementation of GW use restrictions; and implementation of corrective action plan if ACLS are exceeded in the future.	EPA has set ACLs for GW contaminants in order to meet drinking water criteria in SW. Chemical-specific ACL concentrations include benzene 26 mg/L, TCE 26 mg/L, PCE 41 mg/L, and arsenic 260 mg/L.	(Not specified)

Table A-1 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Years 1986-1989

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
7	Chemplex, IA Manufacturing Facility 09/27/89 1st	GW contaminated with VOCs including benzene, toluene, xylenes, TCE, and PCE; and other organics including carcinogenic and noncarcinogenic PAHs.	Not specified	GW pumping and pretreatment followed by treatment of pretreated GW at the existing onsite biological activated sludge wastewater treatment plant with discharge to SW; implementation of GW use and deed restrictions.	GW cleanup goals were derived from Health Advisory Levels (HALs), Negligible Risk Levels (NRLs), Water Quality Criteria (WQC), and MCLs. Specific goals include benzene 1.0 µg/L (NRL), toluene 2,000 µg/L (HAL), PCE 10 µg/L (HAL), TCE 3.0 µg/L (NRL), and xylenes 10,000 µg/L (MCL).	\$2,622,000 (present worth) \$219,600 (annual O&M) (years 1-30)
7	Solid State Circuits, MO Manufacturing Facility 09/27/89 1st - Final	GW contaminated with VOCs including TCE.	57,790,000 gals (GW)	GW pumping and treatment using air stripping with offsite discharge to a POTW; and GW and air monitoring.	GW exceeding TCE 5 µg/L will be remediated at a POTW. GW with TCE levels above 200 µg/L will be treated onsite before discharge to the POTW. Discharge from the POTW must meet the average monthly State NPDES limits of TCE 2 µg/L. GW cleanup goals will meet a 10 ⁻⁶ cancer risk and an HI ratio <1.	\$4,629,000 (present worth) \$445,300 (annual O&M)

Table A-1 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Years 1986-1989

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
8	Sand Creek Industrial, CO Former Pesticide Manufacturing Operation 09/29/89 1st	Soil, onsite buildings, and tanks contaminated with VOCs including TCE and PCE; and other organics including pesticides.	1,000 yd ³ (soil)	<i>In situ</i> vacuum extraction to to remove VOCs from contaminated soil and onsite treatment of off-gas by air stripping; excavation and offsite incineration of soil contaminated with >1,000 mg/kg VOCs, with offsite residual disposal in a RCRA landfill; backfilling; demolition and offsite disposal of buildings; and GW monitoring	Soil target levels were calculated using a soil-water leaching model that assumed GW concentration corresponding to SDWA MCLs or a 10 ⁻⁶ cancer risk level. Chemical-specific cleanup levels were provided for PCE 1,095 µg/kg	\$5,349,600 (present worth) O&M (not specified)

Table A-2
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
1	Old Springfield Landfill, VT Municipal/Industrial Landfill 09/29/90 2nd - Final	Soil and GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes; and other organics including PAHs and PCBs.	120,000 yd ³ (soil)	Capping areas where soil cleanup levels are exceeded; pumping and treating GW and SW; implementing engineering controls; collecting and venting landfill gases, followed by vapor phase carbon adsorption; GW and air monitoring; and implementing institutional controls including deed restrictions.	Chemical-specific soil cleanup goals include PCBs 6,000 µg/kg (risk-based) and PAHs 3,000 µg/kg (risk-based). Chemical-specific GW treatment goals include benzene 5 µg/L (MCL), TCE 5 µg/L (MCL), xylenes 400 µg/L (State standard), and PCE 5 µg/L (proposed MCLs/practical quantitative limit). EPA is invoking a waiver from compliance with the State standard for PCE because of technical impracticability.	\$8,692,800 (present worth) \$123,000 (O&M)
1	Stamina Mills, RI Former Textile Mill 09/28/90 1st - Final	Soil, debris, sediment, and GW contaminated with VOCs including PCE and TCE; other organics including pesticides; and metals including chromium.	550 yd ³ (landfill waste)	Treating VOC-contaminated soil using vacuum extraction, followed by treatment of the extracted gases using an activated carbon filter; excavating landfill waste and sediment, and placing these wastes within the landfill area, followed by capping and installing a leachate collection system; testing, removing, and disposing of septic tanks and their contents offsite; demolishing and removing onsite structures with onsite disposal of all earthen debris and offsite disposal of solid waste; GW pumping and treatment using pressure filtration, UV/hydrogen peroxide; discharging treated GW to SW onsite or to an existing sewer line; GW and SW monitoring; and implementing institutional controls including deed restrictions.	Chemical-specific soil cleanup levels that will ensure attainment of MCLs in GW include TCE 195 µg/kg and PCE 66 µg/kg. Soil levels for chromium were not established since it was only detected in the area to be capped. GW cleanup goals include TCE 5 µg/L (MCL); PCE 5 µg/L (PMCL), and chromium 50 µg/L (National Interim Primary Drinking Water Regulation).	\$4,316,485 (present worth) \$164,400 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	American Thermostat, NY Surface Dump Site 06/29/90 2nd Final	Soil, sediment, sludge, debris, GW, and SW contaminated with VOCs including PCE and TCE; other organics; and metals including arsenic, chromium, and lead.	6,500 yd ³ (soil) 300 yd ³ (sediment) 5 yd ³ (sludge)	Excavating and treating soil and sediment using low temperature enhanced volatilization; backfilling treated soil and sediment and covering with clean soil; pumping and treatment of GW using filtration, air stripping and carbon adsorption followed by reinjection onsite; decontaminating buildings; removing drums, debris, and sludge for offsite treatment and disposal; disposing of all treatment residuals offsite; and conducting GW and air monitoring.	Chemical specific goals for soil include PCE 1 mg/kg and TCE 0.4 mg/kg. GW goals include PCE 5 µg/L, TCE 5 µg/L, arsenic 25 µg/L, chromium 50 µg/L and lead 25 µg/L, all of which are State MCLs.	\$26,102,200 (present worth) \$1,304,300 (annual O&M)
2	Chemical Leaman Tank Lines, NJ Former Liquid Tanker Truck Terminal and Cleaning Operation 09/28/90 1st	GW contaminated with VOCs including benzene, PCE, and TCE; other organics; and metals including arsenic, chromium, and lead.	Not specified	Pumping and treatment of GW using chemical precipitation, air stripping, and granular activated carbon; incinerating fumes from the air stripper onsite; discharging treated water to onsite SW; GW monitoring; and conducting further studies concerning contaminant characterization and design and operation of the treatment system.	Aquifer cleanup levels will utilize both Federal and State Safe Drinking Water Act MCLs including benzene 1 µg/L (State MCL), PCE 1 µg/L (State MCL), TCE 1 µg/L (State MCL), arsenic 50 µg/L (MCL), chromium 50 µg/L (State MCL), and lead 15 µg/L (proposed MCL).	\$5,420,000 (present worth) \$320,000 (O&M)
2	Cinnaminson Groundwater Contamination, NJ Landfill 09/28/90 1st	GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes; other organics including PAHs and phenols; and metals including arsenic, chromium and lead.	Not specified	Pumping and treatment of GW from shallow and deep aquifers using chemical precipitation and biological/granular activated carbon; reinjecting the treated water onsite into the deep aquifer; GW monitoring; and implementing engineering and institutional controls.	Chemical-specific GW cleanup goals are based on the more stringent of SDWA MCLs or State standards, and include benzene 1 µg/L (State), xylenes 44 µg/L (State), and arsenic 50 µg/L (State).	\$20,500,000 (present worth) \$751,000 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Higgins Farm, NJ Cattle Farm 09/24/90 1st	GW contaminated with VOCs including benzene, PCE, TCE, and xylenes; other organics; and metals including lead.	Not specified	Developing, designing and constructing a water main extension and distribution system; installing new carbon adsorption units, as necessary; operating and maintaining existing carbon adsorption units until construction is completed; conducting environmental sampling of residential wells; removing carbon units and private well connections once the permanent water supply is installed; and implementing institutional controls including GW use restrictions. Since the proposed remedy would not restore GW to beneficial use levels, an interim ARAR waiver will be invoked as part of this remedial action.	Chemical-specific ARARs for drinking water include benzene 1.0 µg/L (State MCL), PCE 1.0 µg/L (State MCL), and TCE 1.0 µg/L (State MCL).	\$1,716,000 (present worth) \$28,200 (O&M)
2	Kentucky Ave Wellfield, NY Inactive Municipal Water Supply 09/28/90 2nd	GW contaminated with VOCs including TCE and xylenes; and metals including arsenic, chromium, and lead.	Not specified	Restoring the Kentucky Avenue wellfield as public drinking water supply by constructing two treatment plants; pumping and treatment of GW using filtration to remove inorganics and air stripping/carbon adsorption or UV-oxidation to remove organics; disposing of any treatment residuals offsite; discharging treated water to public water supply, to SW, or reinjecting onsite; GW monitoring; and investigating an additional possible source of onsite contamination.	Goals for discharge of treated GW were chosen as the most stringent of Federal or State MCLs or MCLGs, or other State GW standards. Chemical-specific goals for GW include TCE 5 µg/L (MCL), arsenic 25 µg/L (State), chromium 50 µg/L (MCL), and lead 25 µg/L (State).	\$14,963,900 (present worth) \$905,300 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	King of Prussia, NJ Abandoned Waste Disposal/Recycling Facility 09/28/90 1st	Soil, sediment, sludge, debris and GW contaminated with VOCs including benzene, PCE, and TCE; and metals including chromium and lead.	Not specified	Excavating lagoon sludge, soil adjacent to the lagoons, and sediment in the swale, treating these materials using soil washing for metals removal and redepositing the residual materials in their original location onsite; excavating and disposing of buried drums, their contents, and associated visibly contaminated soil onsite; removing tankers for offsite disposal; GW pumping and treatment using air stripping, followed by reinjecting of GW and offsite disposal or treatment of residuals; conducting additional sampling and analysis of SW, soil, and sediment; and implementing institutional controls including GW use restrictions.	Soil cleanup objectives are based on a 10^{-4} cancer risk to human health, a HI <1, or State Action Levels and include chromium 483 mg/kg (health-based level), copper 3,571 mg/kg (health-based level), lead 500 mg/kg (State), and nickel 1,935 mg/kg (health-based level). GW cleanup levels include PCE 1 µg/L (State), TCE 1 µg/L (State MCL), chromium 1,000 µg/L (State MCL), and nickel 210 µg/L (State MCL).	\$14,889,000 (present worth) \$285,000 (O&M)
2	Lone Pine Landfill, NJ Waste Disposal Facility 09/28/90	GW contaminated with VOCs including benzene, PCE, phenols, TCE, toluene, and xylenes; and metals including arsenic, chromium, and lead.	Not specified	Pumping and treating GW after installing an inceptor drain that is keyed into the water table aquifer to capture contaminated GW; supplementing the drain with extraction wells screened within the Red Bank aquifer; constructing an onsite wastewater treatment plant consisting of air stripping, precipitation/filtration and carbon adsorption to dewatering and testing of residual solids for offsite disposal; reinjecting treated GW or discharging into a recharge trench onsite; GW and SW monitoring; and implementing institutional controls.	Chemical-specific GW cleanup goals include benzene 1 µg/L (State MCL), PCE 1 µg/L (State MCL), phenols 0.0035 µg/L (State), TCE 1 µg/L (State MCL), toluene 50 µg/L (State MCL), xylenes 44 µg/L (State MCL), arsenic 50 µg/L (State MCL), chromium 50 µg/L (State MCL), and lead 50 µg/L (State MCL).	\$10,267,661 (present worth) \$482,600 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Mannheim Avenue Dump, NJ Former Landfill 09/27/90 1st - Final	GW contaminated with VOCs including benzene and TCE.	Not specified	GW pumping and treatment using air stripping, with pretreatment for removal of iron, if necessary; reinjecting the GW onsite with an evaluation of the feasibility of using infiltration basins as an alternate means of discharge; covering the disposal area with clean fill; developing a contingency plan for the installation of individual carbon adsorption units on residential wells, which may become affected by migration of the contaminant plume; monitoring GW and SW; sampling the sediment; performing a treatability study to investigate the need for further treatments to remove toluene, lead, and chromium from GW; and determining the need for off-gas controls on air stripper units.	Chemical-specific goals for GW include TCE 1 µg/L (State MCL) and benzene 1 µg/L (State MCL).	\$4,217,100 (present worth) \$18,600-\$394,100 (O&M, based on differences in treatment and monitoring systems)
2	Metaltec/Aerosystems, NJ Former Metal Manufacturing Plant 09/27/90 2nd - Final	GW contaminated with VOCs including PCE, TCE, toluene, and xylenes; and metals including chromium and lead.	Not specified	Onsite GW pumping and treatment using precipitation, air stripping, and carbon adsorption, followed by discharge of treated GW to onsite SW; disposing of precipitated sludge from the GW treatment process offsite; regenerating spent carbon and disposing of residuals offsite; and GW monitoring.	Chemical-specific GW goals are based on Federal or State MCLs and include PCE 1 µg/L (State MCL), TCE 1 µg/L (State MCL), toluene 2,000 µg/L (MCL), and xylenes 44 µg/L (State MCL).	\$4,348,900 (present worth) \$466,300 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Solvent Savers, NY Former Chemical Waste Recovery Facility 09/28/90 1st - Final	Soil, debris and GW contaminated with VOCs including PCE and TCE; other organics including carcinogenic and noncarcinogenic PAHs, PCBs, and phenols; and metals including arsenic, chromium, and lead.	300 drums 59,000 yd ³ (soil)	Excavating drums followed by treating and disposing drums and associated wastes at an offsite RCRA facility; excavating VOC-contaminated soil followed by treating onsite using low temperature thermal extraction; treating PCB-contaminated soil by same method or by incinerating the soil offsite; treating soil contaminated with low levels of VOCs using soil flushing and/or vapor extraction; treating organic vapors from the soil treatment using an unspecified method; backfilling excavated areas with treatment residuals and clean fill; onsite GW pumping and treatment using chemical precipitation, air stripping, and carbon adsorption, followed by reinjection and/or discharge to SW; offsite disposal of residuals; monitoring air and GW.	Soil cleanup levels are based on an average of model- derived cleanup levels to prevent further GW contamination and include PCE 2.2 mg/kg, TCE 0.8 mg/kg, toluene 1.5 mg/kg, and xylenes 3.1 mg/kg. PCB-contaminated soil will be treated to attain the level of 1 mg/kg (TSCC PCB policy). GW cleanup goals include PCE 5 µg/L (CLP Quantification Limit), TCE 5 µg/L (MCL), arsenic 25 µg/L (State), noncarcinogenic PAHs 32,340 µg/L (health-based), and phenols 48,500 µg/L (health-based).	\$29,350,000 (present worth) \$523,000 (O&M)
3	Croydon TCE, PA Contaminated GW Plume 06/29/90 2nd - Final	GW contaminated with VOCs including TCE and 1,1-DCE.	Not specified	GW pumping and onsite treatment using air stripping and carbon adsorption, followed by onsite discharge; vapor-phase carbon adsorption of air stripper exhaust, followed by offsite disposal or treatment of spent carbon; implementing institutional controls including GW use restrictions; and GW monitoring.	Chemical-specific GW cleanup goals include TCE 1 µg/L and 1,1-DCE 1 µg/L (State and background levels).	\$1,345,000 (present worth) \$46,709 (annual O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1990

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
3	Cryo-Chem, PA Metal Fabricating Facility 09/28/90 2nd	GW contaminated with VOCs including PCE, TCE, DCA, DCE, and TCA.	Not specified	Pumping and treatment of GW using air stripping, followed by carbon adsorption, if emissions are above Clean Air Act levels, with onsite discharge of treated water to SW; and GW and SW monitoring.	GW will be remediated to meet SDWA MCLs, or to an excess cancer risk level of 10^{-6} or less, if no current MCL exists for a particular contaminant. Chemical-specific goals for GW include PCE 5 µg/L (proposed MCL), DCE 0.007 mg/L (MCL), TCA 0.2 mg/L, and TCE 5 µg/L (MCL). SW must meet Clean Water Act Federal Water Quality Criteria FWQC including PCE 0.8 µg/L (FWQC) and TCE 2.7 µg/L (FWQC) for both water and fish ingestion.	\$2,065,000 (present worth) \$75,200 (O&M)
3	East Mt. Zion, PA Inactive Landfill 06/29/90 1st - Final	GW contaminated with VOCs including benzene and vinyl chloride.	Not specified	Capping the landfill with an impermeable multi-layer cap; constructing a passive venting system to control methane offgasses; installing SW control systems for the cap; allowing natural attenuation to reduce GW contamination to background levels; conducting GW monitoring; and implementing institutional controls including deed restrictions and site access restrictions including fencing.	Based on GW velocity and elimination of the source, GW concentrations are expected to meet background levels within 5 years through natural attenuation. Chemical-specific goals for GW include benzene 5 µg/L (MCL) and vinyl chloride 2 µg/L (MCL).	\$2,230,000 (present worth) O&M (not specified)
3	Lord Shope Landfill, PA Inactive Hazardous Waste Landfill 06/29/90 1st - Final	Landfill material, soil, and GW contaminated with VOCs including benzene, PCE, and TCE; and metals including arsenic, chromium, and lead.	Not specified	<i>In situ</i> vapor stripping of landfill material and soil using vacuum wells; collection and treatment of gas emissions generated by the vapor stripping process using carbon adsorption; GW pumping and treatment, followed by air stripping, with final discharge of treated GW into the nearby surface tributaries; implementation of site access restrictions, and institutional controls including GW use restrictions.	Chemical-specific goals for soil will be determined during the remedial design. Chemical-specific GW cleanup goals will include PCE 5 µg/L (PMCL), TCE 5 µg/L (MCL), benzene 5 µg/L (MCL), arsenic 20 µg/L (based on an excess cancer risk of 10^{-4}), chromium 50 µg/L (MCL), and lead 15 µg/L (risk-based calculation).	\$5,760,000 (present worth) \$420,000 (O&M) (years 0-2) \$310,000 (O&M) (years 3-50)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
3	Raymark, PA Active Metal Manufacturing and Electroplating Plant 09/28/90 1st	GW contaminated with VOCs including TCE and PCE.	Not specified	Continuing operation and maintenance of the Hatboro public supply and the existing air stripping towers at the wells as well as installation of new vapor phase carbon adsorption units; completing a GW remedial design study; onsite pumping and treatment of GW with air stripping and vapor phase carbon adsorption units with offsite disposal to Pennypack Creek; and implementing institutional controls.	GW will meet SDWA MCLs, non-zero MCLGs, or background levels, whichever are more restrictive. The residual excess cancer risk resulting from site-related contamination will be reduced to a HI=1. Chemical-specific levels for GW include TCE 5 µg/L (MCL) and PCE 5 µg/L (proposed MCL).	\$2,700,000 (present worth) \$125,000 (O&M)
3	Ott/Story/Cordova Chemical, WI Chemical Manufacturing Facility 09/29/90 2nd	GW contaminated with VOCs including benzene, PCE, TCE, toluene, vinyl chloride, 1,2-dichloroethane, and xylenes; other organics including pesticides; and metals including arsenic.	Not specified	Pumping and treatment of GW in the shallow and deeper zones of the aquifer system using physical-chemical treatment including UV-oxidation, air stripping, biological treatment such as activated sludge, and/or filtration/adsorption such as granular activated carbon; discharging the treated effluent into the nearby stream; installing a GW monitoring system, and implementing institutional controls to limit GW use.	Chemical-specific GW cleanup goals include benzene 1 µg/L (10 ⁻⁶ cancer risk level), toluene 40 µg/L (State standard), TCE 3 µg/L (10 ⁻⁶ cancer risk level), and xylenes 20 µg/L (State standard). Effluents must meet limitations for stream discharge as administered by the State.	\$26,000,000 (present worth) \$1,400,000 (annual O&M)
4	City Industries, FL Former Hazardous Waste Recycling and Transfer Facility 03/29/90 1st	GW contaminated with VOCs including benzene, PCE, TCE, and toluene.	Not specified	Pumping and treatment of GW using air stripping, followed by offsite discharge to a publicly owned treatment works (POTW), if treatability studies show the discharged water to be acceptable for POTW discharge	Chemical-specific goals for GW include benzene 1.0 µg/L (State drinking water standard), PCE 3 µg/L (State drinking water standard), TCE 3.0 µg/L (State drinking water standard), and toluene 2,000 µg/L (proposed MCLG).	\$4,575,632 (present worth) \$292,500 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
4	Dubose Oil Products, FL Inactive Waste Storage, Treatment, and Disposal Facility 03/29/90 1st - Final	Soil, sediment, GW, and SW contaminated with VOCs including benzene, TCE, toluene, and xylenes; other organics including PAHs and phenols.	Not specified	Excavating the top 20 ft. of vault soil containing low-level contamination and disposing of soil in an onsite ravine area; excavating remaining vault soil and treating by aerobic biodegradation, which includes windrowing of soil on a concrete slab, addition of microbial seed and nutrients, and aeration; disposing of treated soil onsite in the ravine area; placing a 2 ft. soil cover over the vault and ravine areas; treating soil leachate from the windrowing process using filtration and either carbon adsorption or UV oxidation, followed by onsite discharge to SW; draining and filling of onsite ponds; installing SW runoff controls; conducting GW and soil monitoring; restoring GW by natural attenuation; and implementing institutional controls including deed and GW use restrictions.	Cleanup standards for leachate discharge are based on the more stringent of Federal or State ARARs and include benzene 1 µg/L (State), TCE 3 µg/L (State), xylenes 50 µg/L (State), and PNAs 10 µg/L (EPA detection limit). Soil cleanup are based on either leaching potential (LP) or health-based criteria (HBC) and include benzene 10 mg/kg (HBC), TCE 0.050 mg/kg (LP), xylenes 1.5 mg/kg (LP), and PAHs 50 mg/kg (LP).	\$3,008,000 (present worth) \$115,000 (O&M) (years 0-5) \$10,000 (O&M) (years 6-10)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
4	Jadco-Hughes, NC Former Solvent Reclamation and Waste Storage Facility 09/27/90 1st Final	Soil, GW, and SW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes; other organics including PCBs and phenols; and metals including arsenic, chromium, and lead.	Not specified	Soil venting followed by vacuum extraction and carbon adsorption to remove VOCs and other organics; flushing the treated soil, then collecting and treating the residual water in a GW treatment system; collecting GW with a subsurface drain system; pumping GW from highly contaminated areas followed by pretreatment using aeration and carbon adsorption to reduce VOCs and subsequent offsite discharge to a publicly owned treatment works (POTW); conducting a treatability study to ensure compliance with POTW pretreatment standards; replacing an onsite SW culvert; monitoring GW and SW; sampling soil and sediment; and implementing institutional controls including land and GW use restrictions. The contingency remedy includes GW pumping and treatment using ultraviolet oxidation with discharge to an onsite tributary.	Both soil and GW cleanup goals were developed to remediate and protect the GW. Chemical-specific cleanup goals for soil include PCBs 10.0 mg/kg (TSCA), arsenic 48.0 mg/kg (background), chromium 140.0 mg/kg (background), and lead 1.3 mg/kg. Treatment goals for GW include benzene 1 µg/L (State), PCE 0.7 µg/L (State), phenols 4,200 µg/L (RID), TCE 2.8 µg/L (State), toluene 1,000 µg/L (State), xylenes 400 µg/L (State), arsenic 50 µg/L (State), chromium 50 µg/L (State), and lead 15 µg/L. Recommended Cleanup Goal for Superfund Sites).	\$4,830,900 (present worth) (includes estimated present value) \$2,665,600 (O&M) (no costs were provided for the contingency remedy)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
4	SCRDI Bluff Road, SC Inactive Chemical Waste Manufacturing, Storage, Recycling, and Disposal Facility 09/12/90 1st - Final	Soil and GW contaminated with VOCs including benzene, toluene, TCE, and xylenes; other organics including PCBs, phenols, and pesticides; and metals.	Not specified	Pumping and onsite treatment of GW using flocculation/precipitation as a pretreatment to remove metals, air stripping to remove VOCs, and granular activated carbon adsorption to remove semi-volatile organic compounds, if necessary, followed by reinjecting the treated water onsite; treating contaminated soil <i>in situ</i> using vacuum extraction, followed by carbon adsorption or fume incineration to destroy off-gasses; managing carbon residuals from GW and soil treatments through offsite disposal or regeneration; and monitoring soil and GW.	Chemical-specific GW cleanup goals include benzene 5 µg/L (MCL), PCE 5 µg/L (MCL), TCE 5 µg/L (MCL), toluene 2 mg/L (MCL), and xylenes 10 mg/L (MCL). Chemical-specific goals for soil include benzene 12 µg/kg (SL), PCE 53 µg/kg (SL), TCE 18 µg/kg (SL), toluene 3.95 mg/kg (SL).	\$5,574,984 (present worth) \$311,287 (O&M)
5	Clare Water Supply, MI Municipal Wellfield 08/30/90 1st	GW contaminated with VOCs including TCE.	Not specified	Installing and operating an air stripper to treat GW, modifying pipelines on the existing water supply system, and monitoring air emissions from the air stripping process.	This ROD will remediate GW TCE and TCE-degradation components to meet Safe Drinking Water Act MCLs including TCE 5 µg/L. Additional chemical-specific GW goals will be determined in the subsequent ROD.	\$1,284,059 (present worth) \$61,000 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Fisher Calo Chem, IN Chemical Manufacturing 08/07/90 1st - Final	Soil, debris, and GW contaminated with VOCs including TCE, toluene, xylenes; other organics including PAHs and PCBs; and asbestos.	Not specified	Excavating and incinerating of semi-volatile and PCB-contaminated soil, with ash disposal location to be determined upon leaching test results; treatment of VOC-contaminated soil remaining in the excavated area using soil flushing or vapor extraction; limited asbestos removal/repair of structures and offsite disposal of any asbestos-containing materials, drums, tanks, or containers and their contents; pumping and treatment of GW using and equalization/sedimentation basin, granular activated carbon, and air stripping, followed by filtration and reinjection of the treated water into the shallow aquifer; construction of GW production well; GW monitoring; and implementation of site access restrictions.	Excavation levels for contaminated soil are based on TSCA standards and TBC criteria, including PCBs 10 mg/kg. GW cleanup levels adopted by the State from SDWA MCLs and MCLGs, including TCE 5 µg/L.	\$31,685,000 (present worth) \$9,379,000 (annual O&M)
5	Hunt's Disposal, WI Inactive Landfill 09/29/90 1st - Final	Soil, sediment, debris, and GW contaminated with VOCs including benzene, TCE, and xylenes; acids; and metals including arsenic and chromium.	5,300 yd ³ (soil and sediment)	Excavating and consolidating onsite contaminated soil and sediment from outside the landfill area to within the landfill; filling excavated areas with clean soil; constructing a levee; capping the landfill; installing an active landfill gas collection and combustion system; constructing a slurry wall; pumping and offsite treatment of GW, followed by offsite discharge; and implementing institutional controls including land and GW use restrictions, and site access restrictions including fencing.		\$17,454,000 (present worth) \$375,000 (annual O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	K&L Landfill, MI Inactive Municipal Landfill 09/28/90 1st - Final	Soil, debris, and GW contaminated with VOCs including vinyl chloride, benzene, toluene, and xylenes; other organics including acids, PAHs, PCBs, and phenols; and metals including chromium and lead.	Not specified	Capping the landfill area with a RCRA multi-layer cap and installing gas vents throughout the landfill; pumping and treatment of GW using enhanced bioremediation/fixed-film bioreactor technology accompanied by aeration; conducting treatability studies or pilot tests to ensure remedy effectiveness; discharge of treated effluent with onsite reinjection, discharge to an onsite filtration pond, or offsite discharge to a publicly owned treatment works (POTW), with offsite disposal of any resulting sludge; continued GW, SW and air monitoring; closure of affected residential wells; and implementing institutional controls including deed restrictions.	Chemical-specific goals for GW include acetone 700 µg/L (State), benzene 1.0 µg/L (State), toluene 40 µg/L (State), vinyl chloride 0.02 µg/L (State), xylenes 20 µg/L (State), phenols 300 µg/L (State), and lead 5 µg/L (State).	\$16,407,100 (present worth) \$1,099,900 (O&M)
5	Kummer Sanitary Landfill, MN Inactive Municipal Landfill 09/29/90 3rd - Final	GW contaminated with VOCs including benzene, PCE, TCE, and vinyl chloride.	Not specified	Pumping and treatment of GW using advanced oxidation processes (e.g., ozone, hydrogen peroxide, or ultraviolet light), and lime soda softening as necessary, to precipitate inorganic compounds, followed by disposal of the precipitant sludge, polishing the effluent stream with granulated activated carbon, and discharging treated GW to an onsite infiltration pond; and GW monitoring.	Contaminants of concern in the GW will be reduced to meet current and proposed Maximum Contaminant Levels (MCLs), including PCE 5 µg/L (proposed MCL), TCE 5 µg/L (MCL), and benzene 5 µg/L (MCL); thereby reducing cumulative residual carcinogenic risk due to ingestion to 10 ⁻⁶ .	\$1,800,000-\$6,200,000 (present worth) \$240,000-\$510,000 (annual O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Metamora Landfill, MI Inactive Landfill 09/28/90 2nd	Debris and GW contaminated with VOCs including benzene, PCE, TCE, and xylenes; and metals including arsenic and barium.	Not specified	Pumping and treatment of GW using precipitation/flocculation with air stripping and adsorption and reinjection of treated water into the shallow aquifer; offsite treatment and disposal of secondary waste streams including flocculation sludge and spent carbon; capping the landfill area using a multi-layer clay cap, and collection and flaring of landfill gases; monitoring GW; and use restrictions; and site access restrictive such as fencing.	Chemical-specific cleanup goals for GW are based on Michigan Act 307 rules as well as MCLs including benzene 1 µg/L (State), PCE 0.7 µg/L (State), TCE 3.0 µg/L (State), and arsenic 0.02 µg/L (State) or background.	\$19,354,050 (present worth) \$856,944 (annual O&M)
5	Naval Industrial Reserve Ordinance Plant, MN Federal Facility 09/28/90 1st	GW contaminated with VOCs including PCE, TCE, toluene, and xylenes.	Not specified	Pumping and pretreatment of GW, as necessary, prior to disposal to a local publicly owned treatment (POTW) via an exiting sanitary sewer system; and testing the recovered water to assist in the design of GW treatment facilities; treating recovered GW by either a two-stage air stripping process, followed by vapor-phase granular activated carbon (GAC) to treat air emissions, or treating GW using aqueous-phase GAC, depending on testing results; and discharging treated GW. Both options include disposal of the effluent offsite and regenerating spent carbon at an offsite facility.	GW quality in the unconsolidated aquifer will be restored to MCLs or State recommended allowable limits, if more restrictive. The target GW cleanup goal for TCE is 5.0 µg/L (MCL). Cleanup levels for VOCs in recovered GW discharged to the local POTW must not exceed 10 mg/L and individual VOC levels must be <3 mg/L (local POTW standards). Contaminants in any uncaptured portion of the aquifer are expected to dissipate through natural means.	\$4,100,000 (present worth) O&M (not specified)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Springfield Township Dump, MI Industrial Waste Disposal Area 09/29/90	Soil and GW contaminated by VOCs including TCE and toluene; other organics including PCBs; and metals including arsenic, chromium, and lead.	11,820 yd ³ (soil)	Excavating and treating VOC and other organic-contaminated soil onsite by incineration, and solidifying the resulting ash; treating metal-contaminated soil using solidification and redepositing the treated soil onsite, or temporarily storing the treated soil onsite in a solid waste unit; treating remaining contaminated soil and ash onsite, or temporarily storing the treated soil using <i>in situ</i> vacuum extraction with treatability studies to determine its effectiveness; GW pumping and treatment using carbon adsorption, followed by onsite reinjection of treated water; and implementing site access restrictions such as fencing.	Soil remediation goals are based on a 10 ⁻⁶ cancer risk and State Michigan Act 307 Standards. Chemical-specific soil cleanup levels include PCBs 1 mg/kg, toluene 0.08 mg/kg, and TCE 0.08 mg/kg. Groundwater will be remediated to meet or exceed SDWA MCLs or MCLGs, including toluene 0.4 mg/L (MCL) and TCE 0.003 mg/L MCL). Lead and arsenic will be remediated for both soil and groundwater.	\$9,271,290 (present worth) \$97,659 (annual O&M)

Table A-2 (Cont.)
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Wayne Waste Oil, IN Former Oil Reclamation Facility and Landfill 03/30/90 1st - Final	Soil, debris, and GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes; other organics including PAHs and phenols; and metals including arsenic, chromium, and lead.	Not specified	Treating VOC-contaminated soil using vapor extraction; treating metals-contaminated soil using soil washing or solidification/stabilization; delineating the area of the municipal landfill; capping the landfill and constructing a landfill venting system if necessary; covering PAH-contaminated soil or consolidating the soil under the landfill cap; treating contents of storage tanks offsite and steam cleaning and removing the storage tanks offsite; dismantling the incinerator and disposing of the debris offsite or within the onsite municipal landfill; pumping and treatment of GW onsite using air stripping, or discharging the GW offsite to a publicly owned treatment works (POTW); monitoring air, GW, and SW; and implementing institutional controls including deed, land use, and GW use restrictions, and site access restrictions such as fencing.	Soil cleanup levels will be calculated using a contaminant leaching model. Chemical-specific cleanup levels for GW include benzene 5 µg/L (MCL), PCE 5 µg/L (MCL), TCE 5 µg/L (MCL), toluene 2,000 µg/L (MCL), xylenes 10,000 µg/L (proposed MCL), and arsenic 50 µg/L (MCL).	\$5,582,499 (present worth) \$291,000 (annual O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
6	Tinker AFB (Soldier Creek/Bldg. 3001), OK Federal Facility 08/16/90 1st	Soil, debris, and GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes; other organics including phenols; and metals including chromium and lead.	6,000-12,000 gals	Pumping and onsite treatment of GW using air stripping, precipitation, and fine filtration; using the treated water in onsite industrial processes; disposing of any residuals from the treatment processes offsite; recovering hydrocarbons by using a dual fluid production system followed by offsite disposal; removing liquid waste from pit Q-51; placing liquid waste into 55-gallon drums; steam cleaning, backfilling, and covering the pit; storing drums temporarily onsite; removing and disposing of a 750-gallon waste tank and properly abandoning, demolishing, and backfilling the onsite fuel oil tank at the North Tank Area; treating soil from the North Tank Area using vapor extraction with destruction of vapors in a thermal combustor; and GW monitoring.	Soil remediation goals include a 99% removal of organic contaminants at the North Tank Area. Chemical-specific GW cleanup goals include benzene 5 µg/L (MCL), PCE 5 µg/L (MCL), TCE 5 µg/L (MCL), chromium 50 µg/L (MCL), and lead 50 µg/L (MCL).	\$13,198,308 (present worth) O&M (not specified)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
7	Missouri Electric Works, MO Electrical Equipment Sales, Service, and Remanufacturing Operations 09/28/90 1st - Final	Soil, sediment, and GW contaminated with VOCs including benzene, PCE, and TCE; and other organics including PCBs.	Not specified	Excavating and treating PCB-contaminated soil and sediment onsite using incineration; placing exhaust gases through flue-gas coolers and particulate removal systems; backfilling with residual materials based on leachability test results; constructing a soil cover over the site; pumping and treatment of GW with filtration and treatment using air stripping with subsequent carbon adsorption; and discharging the treated water offsite to a surface drainage ditch between the site and the wetlands or to a publicly owned treatment works (POTW).	Contaminant levels for soil and sediment after treatment will represent an excess upper bound lifetime cancer risk of 2×10^{-5} . Cleanup levels for GW will be 10^{-5} and cleanup levels meet the TSCA PCB Spill Cleanup Policy, State water quality standards, and Federal MCLs for VOCs. Specific goals include TCE 5 µg/L (MCL) for GW, PCB 10 mg/kg (TSCA) for soil to a depth of 4 ft., and PCB 10 mg/kg (TSCA) for soil below a 4-ft. depth.	\$9,130,000 (present worth) \$64,010 (O&M)
7	Wheeling Disposal Service, MO Inactive Industrial and Sanitary Landfill 09/27/90 1st	Soil, sediment, GW and SW contaminated with VOCs including TCE and toluene; other organics including pesticides; and metals including arsenic, chromium and lead.	Not specified	Upgrading the existing landfill cap with a revegetated clay and soil cover; monitoring onsite GW and SW; abandoning onsite wells; and implementing institutional controls including deed restrictions, and site access restrictions such as fencing.	Performance criteria for GW and SW will be developed, and may be based on Federal MCLs, Ambient Water Quality Criteria, or State water quality standards. If contaminated levels exceed these criteria, GW treatment and/or leachate collection and treatment may be required.	\$1,205,800 (present worth) \$42,000 (O&M)
7	Lindsay Manufacturing, NE Irrigation Sprinkler Manufacturing Facility 09/28/90 1st - Final	Soil and GW contaminated with VOCs including PCE; and metals including chromium and lead.	Not specified	Treating soil using vacuum extraction (SVE), followed by a carbon adsorption filter system before vapor emission with full-scale implementation based on the results of a pilot study; onsite pumping and treatment of GW using precipitation and flocculation, followed by sedimentation of the flocculent with onsite discharge to SW; and disposing of dewatered solid residuals offsite at a local landfill.	Cleanup levels are based on the more stringent of either SDWA MCLs or State regulations. Specific GW cleanup goals include PCE 5 µg/L (proposed MCL), chromium 0.05 mg/L (MCL), and lead 0.05 mg/L (MCL). Specific cleanup levels for soil were not provided.	\$3,006,600 (present worth) \$636,000 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
8	Martin Marietta Denver Aerospace, CO Technology Engineering, Design, Development, and Manufacturing Facility 09/24/90 1st	Soil, debris, and GW contaminated with VOCs including TCE, toluene, xylenes; other organics including PCBs, pesticides and phenols; and metals including chromium and lead.	24,000 yd ³ (soil) 2,100 yd ³ (debris)	Remediation of the Inactive Ponds Area includes dewatering perched water zones; excavating and incinerating offsite 2,100 yd ³ of organic waste/soil from in and around the ponds; thermally treating 24,000 yd ³ of organic-contaminated soil; solidifying and stabilizing remaining soil contaminated with inorganics; backfilling excavated areas with treated soil; and capping the ponds area. Remediation of the Chemical Storage Area includes <i>in situ</i> soil vapor extraction and incineration of VOC-contaminated soil, followed by offsite disposal of residuals and spent carbon. Onsite pumping and treatment of GW using air stripping, carbon adsorption, ion exchange, UV photolysis/oxidation, chemical reduction, and precipitation, followed by onsite discharge to SW; and GW monitoring.	Both onsite and offsite GW will be treated to meet SDWA MCLs or MCLGs, including benzene 5 µg/L (MCL), arsenic 50 µg/L (MCL), chromium 50 µg/L (MCL), lead 5 µg/L (MCL) and TCE 5 µg/L (MCL). Chemical-specific soil cleanup levels are based on soil action levels and TCLP treatment standards including toluene 28 mg/kg (TCLP), PCB 1.0 mg/kg (TCLP), and TCE 0.09 mg/kg (TCLP).	\$58,240,000 (present worth) \$1,231,500 (annual O&M)
8	Mystery Bridge at Highway 20, WY Industrial Area with Residential Subdivisions 09/24/90 1st	GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes.	Not specified	Pumping and treatment of GW in the VHO plume followed by air stripping in the more contaminated upgradient portion of the plume; pumping and treatment of GW in the BETX plume using air stripping; reinjecting the treated GW from both plumes into the onsite alluvial aquifer; GW and air monitoring; and implementing institutional controls including deed and GW use restrictions.	Chemical-specific GW cleanup goals are based on Safe Drinking Water Act MCLs including benzene 5 µg/L (MCL), toluene 2,000 µg/L (proposed MCL), xylenes 10,000 µg/L (proposed MCL).	\$601,739 (present worth) \$122,914 (O&M) (for 6 years at the VHO plume) \$50,564 (O&M) (for 1 year at the BETX plume)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
8	Rocky Flats Plant (DOE), CO Federal Facility 01/05/90 1st	GW contaminated with VOCs including PCE and TCE; metals including chromium; and radioactive materials.	Not specified	Intercepting GW in alluvial/colluvial aquifer using french drain system with treatment in an onsite plant using filtration; followed by UV-peroxide to remove organics, and ion exchange to remove inorganics; storing treated water temporarily onsite during effluent quality testing prior to discharging the treated water to an onsite interceptor ditch; and GW monitoring.	GW cleanup standards have been chosen as the more stringent of Federal MCLs or MCLGs, or State water quality standards and include PCE 5 µg/L (State), TCE 5 µg/L (State), trivalent chromium 0.05 mg/L (State), and chromium 0.05 mg/L (State).	\$4,588,200 (present worth) \$258,100 (O&M)
9	Applied Materials, CA Active Equipment Facility 09/28/90 1st	GW contaminated with VOCs including PCE, TCE, and 1,1,1-TCA.	Not specified	Pumping and treatment of GW onsite using an existing air stripping unit, followed by onsite discharge to surface water; GW monitoring; and implementing institutional controls including deed restrictions.	GW cleanup levels will meet State and Federal Drinking Water MCLs including PCE 0.005 µg/L (MCL), TCE 0.005 µg/L (MCL) and 1,1,1-TCA 0.0032 µg/L (MCL).	\$715,000 (present worth) O&M (not specified)
9	Intel (Santa Clara III), CA Industrial Facilities Area 09/20/90 1st - Final	GW contaminated with VOCs including TCE.	Not specified	Installing an additional extraction well onsite; continued pumping and treatment of GW using an existing granular activated carbon adsorption system, with regeneration of carbon filters offsite; discharging treated GW to onsite SW; conducting a treatability study to evaluate the effectiveness of pulse pumping; GW monitoring; and implementing institutional controls including deed restrictions to limit GW use.	GW cleanup goals will reduce the excess lifetime cancer risk for carcinogens from 10^{-4} to 10^{-6} and will reduce the HI to ≤ 1 . Chemical-specific goals include TCE 5 µg/L (State MCL).	\$594,000 (present worth) O&M (not specified)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
9	Intersil, CA Industrial Facilities 09/27/90 1st - Final	Soil and GW contaminated with VOCs including PCE, TCE, and toluene; and other organics including phenols.	40 yd ³ (soil)	Enhancement and/or expansion of onsite and offsite GW pumping and treatment systems, which use air stripping, and the onsite soil vapor extraction systems, which use carbon adsorption at the Siemens and Intersil facilities; excavating soil at the Siemens facility, followed by offsite disposal; discharging treated GW to onsite SW; and monitoring soil vapor and GW.	Soil cleanup goals have been set at total VOCs 1 mg/kg, which are excavated and disposed of offsite. GW cleanup standards were chosen as the more stringent of Federal or State MCLs, or State Recommended Drinking Water Action Levels (RDWALs). Chemical-specific goals include PCE 5 µg/L (State MCL), TCE 5 µg/L (State MCL) and toluene 100 µg/L (RDWAL).	\$17,750,000 (present worth) O&M (not specified)
9	Solvent Service, CA Active Treatment, Storage, and Disposal Facility 09/27/90 1st - Final	Soil and GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes.	Not specified	Capping the entire site with asphalt; operating a steam injection and vacuum extraction (SIVE) system for the removal of VOCs from soil; pumping and treatment of GW using biotreatment carbon adsorption, and air stripping soil and GW monitoring; and implementing institutional controls including deed restrictions.	A soil remediation goal of 1 µg/L total VOCs has been set to protect the GW from future VOC leaching. Inorganic soil cleanup goals have not been established due to uncertainty surrounding the natural occurrence of metals in soil in the South Bay area. GW remediation goals include benzene 1 µg/L (State MCL), PCE 5 µg/L (State MCL), TCE 5 µg/L (State MCL), toluene 1,000 µg/L (Federal MCL), and xylenes 1,750 µg/L (State MCL).	\$948,000 (capital) \$1,172,000 (O&M)

Table A-2 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
9	Watkins-Johnson (Stewart Division), CA Active Industrial Complex 06/29/90 1st - Final	Soil and GW contaminated with VOCs including PCE and TCE, and metals including silver.	Not specified	Soil vapor (vacuum) extraction with pretreatment of extracted vapors using GAC prior to ambient discharge; capping and grading contaminated soil areas to minimize the potential for mobilization of soil contaminants to GW; installing infiltration leachfields to prevent offsite migration of GW contaminants in the perched zone; installing gravity drains to transfer contaminated GW from the perched zone to the regional aquifer zone for subsequent extraction; GW pumping and onsite treatment using GAC adsorption with offsite regeneration of spent carbon; onsite discharge of treated water for reuse or offsite discharge to SW; and GW monitoring.	GW treatment standards for both the perched and regional zones were based on chemical-specific SDWA MCLGs or the more stringent of SDWA MCLs or PMCLs and State MCLs. Chemical-specific goals include PCE 0.005 mg/L (PMCL) and TCE 0.005 mg/L (MCL). No chemical-specific goals have been set for soil.	\$2,156,243 (present worth) \$167,820 (O&M)
10	Fort Lewis Logistics Center, WA Federal Facility 09/25/90 1st	GW contaminated with VOCs including PCE, TCE, and DCE.	Not specified	Pumping and onsite treatment of GW using air stripping to remove VOCs discharging the treated water onsite to infiltration trenches, including one trench located upgradient to facilitate flushing of secondary contaminant sources; confirmation soil sampling; investigating deep aquifer contamination for possible remediation; and implementing institutional controls.	GW cleanup standards are based on Federal MCLs and include PCE 5 µg/L, TCE 5 µg/L, and DCE 70 mg/L.	\$9,068,000 (present worth) \$517,000 (O&M exclusive of maintenance)

Table A-3
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
9	Advanced Micro #915 Devron, CA 8/26/91	GW contaminated with VOCs including benzene, TCE, toluene, and xylenes, other organics; and metals including arsenic and chromium	Not specified	GW pump and treat using air stripping and carbon adsorption and discharge of treated water onsite to surface water.	GW cleanup standards are based on the more stringent federal or state MCLs for drinking water including PCE 5 µg/L and TCE 5 µg/L	\$2,100,000 (O&M costs for 30 years)
1	Dover Municipal Landfill, NH 9/10/91	Soil, sediment, sludge, debris, and GW are contaminated with VOCs including benzene, PCE, TCE, toluene, and vinyl chloride; other organics; and metals including arsenic	Not specified	Recontouring of the existing landfill; consolidation of sediments in the perimeter drainage ditch; limited excavation and consolidation of sediment in the drainage swale and at the confluence to the Cochero River; Capping of the landfill; Upgradient GW diversion; GW/leachate collection and treatment; Additional monitoring wells; Natural attenuation of plume; GW extraction and treatment; Long-term environmental monitoring; Institutional controls.	Final GW clean-up levels will be determined as a result of an RA performed on residual GW after all interim clean-up levels have been met; Performance standard; sediment in areas where arsenic levels are above 50 mg/kg will be excavated and consolidated under the landfill cap; GW interim clean-up goals are based on the more stringent of Federal MCLs for non-zero MCLGS, EPA health advisories, state standards, or reference doses and include arsenic 50 µg/L (RCRA MCL) or background; benzene 5 µg/L PCE µg/L TCE 5 µg/L	\$24,155,700 includes: \$157,680 (10 years O&M) \$721,600 (annual cost for 30 years of GW monitoring)
3	Arco Lycoming, PA 6/28/91	Onsite GW contaminated with VOCs including TCE and metals including chromium	Not specified	Pump and treatment of contaminated GW utilizing precipitation, coagulation, flocculation, and air-stripping. Air stripper gases treated using BAT. Dewatering and offsite disposal of residual precipitation sludge and spent carbon filter. Discharge of treated water onsite to surface water, monitoring groundwater and implementing institutional controls including land use restrictions.	GW clean-up standards are based on the more stringent of federal MCLs or non-zero MCLGs, or background levels. No chemical-specific goals are provided.	\$9,300,000 includes: \$442,900 (annual O&M cost for 30 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
10	American LK Gardens, WA 9/19/91	Onsite and offsite GW contaminated with VOCs including benzene, PCE, TCE, toluene, and xylenes. Other organics; and metal including arsenic, chromium, and lead.	Not specified	Pump and treatment of both onsite and offsite GW using a multi-bed carbon. Adsorption treatment facility, followed by recharging or irrigating the treated GW onsite; regenerating the spent carbon offsite; monitoring the GW plume; and implementing institutional controls.	GW will be restored to levels consistent with states and federal MCLs; cis-1,2-CDE 70 µg/L 1,1-DCE 0.7 µg/L TCE 5 mg/L vinyl chloride 0.04 µg/L	\$4,445,000 to \$6,949,000 includes: \$341,000 (annual O&M costs for years 0-2) \$318,00 (annual O&M costs for years 3-30)
9	Mesa Area Groundwater Contamination, AZ 9/27/91	Soil and GW contaminated with VOCs including PCE and TCE.	Not specified	Treatment of onsite soil using soil vapor extraction, controlling VOC emissions using carbon and adsorption, followed by offsite disposal of carbon residuals; onsite and offsite pumping of contaminated GW; treating the GW onsite using vacuum degasification, followed by carbon adsorption to remove VOCs; discharging the treated water from the degasifier to the deionized water treatment plant for reuse; disposing of remaining wastewater at a POTW; and rehabilitation of 2 industrial GW supply wells.	Soil clean-up goals are based on state standards, including: PCE mg/kg GW clean-up goals are based on SDWA MCLs, including: PCE:5 µg/L TCE:5 µg/L	\$7,144,000 includes: \$581,000 (annual O&M cost for 13 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1991

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Colesville Municipal Landfill, NY 3/29/91	Soil, sediment, debris, and GW are contaminated with VOCs including benzene, PCE, TCA, TCE, and metals including arsenic.	Unspecified	Cutting and regrading the sites and surface of the landfill; constructing lined leachate collection trenches; installing a multi-media cap over the existing landfill; installing a gravel gas venting layer in the landfill, pump and treatment of the GW using air stripping and metals treatment, discharge of the treated water onsite after ultra-violet disinfection and institutional controls.	Clean-up goals are based on the more stringent of state or federal MCLs including: Benzene:5 µg/L PCE:5 µg/L TCE:5 µg/L Xylenes:5 µg/L	\$5,135,000 includes: \$250,000 (annual O&M cost for 4 years)
8	Hill Air Force Base, UT 9/30/91	GW and soil contaminated with VOCs including PCE, TCE, toluene, and xylenes	100,000 to 1,000,000 gallons of TCE bottoms, sludge from vapor degreasers and plating tank sludge bottoms	Source recovery system to remove DNAPL; pumping DNAPL contaminated GW with onsite discharge to pretreatment facility to separate DNAPL from GW using a stream stripper; transport water offsite for incineration, treating pretreated GW using air stripping, followed by carbon adsorption, discharging offsite to a POTW; and monitoring DNAPL collection and treatment during remediation activities.	Goals will be set in a future ROD	\$3,710,000 includes: \$1,000,000 (annual O&M cost for 2 years)
2	South Jersey Clothing Company, NJ	Soil and GW contaminated with VOCs including benzene, PCE, TCE, and Toluene	1,600 cubic yards of soil GW: Not specified	In-situ vapor extraction of soil; air stripping to treat wastewater from vapor extraction processes; treat air emissions using carbon adsorption; pumping and onsite treatment of GW using air stripping and carbon adsorption followed by reinjection upgradient; long-term GW monitoring institutional controls.	Interim soil action level cleanup goals of: PCE1,000 µg/kg TCE1,000 µg/kg GW remediation goals are based on SDWA federal and state MCLS including: PCE1 µg/L TCE1 µg/L	\$5,718,000 includes: \$293,100 (annual O&M cost for 70 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1991

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Kentwood Landfill, MI 3/29/91	GW, debris, and leachate contaminated with VOC s including benzene, PCE, and TCE; other organics; and metals including benzene, PCE, and TCE; other organics; and metals including arsenic, chromium and lead.	Not specified	Update of landfill cap to include gas controls and a leachate collection system; pumping and pretreating GW and leachate onsite; discharge to a POTW or onsite surface water; monitoring sediment, GW, SW, and implementing institutional controls	Clean-up goals are based on SDWA MCLs and state standards including: Benzene:1 µg/L PCE:0.7 µg/L TCE:3 µg/L Arsenic:0.02 µg/L Chromium:30 µg/L Lead:5 µg/L	\$5,700,000 includes: \$210,000 (annual O&M costs for years 0-9) \$200,000 (annual O&M costs for years 10-30)
3	Arrowhead Associates/Scovill, VA 9/30/91	Soil and GW: Benzene, toluene, PCE, TCE, xylenes, chromium, and lead	Not specified	In-situ vacuum extraction of soils; pump and treat using precipitation, flocculation/sedimentation, and filtration, followed by air stripping and carbon adsorption; onsite discharge of treated water; offsite disposal of sludge and residues; carbon adsorption to treat off gases from soils and GW; environmental monitoring; institutional controls.	Soil clean-up goals will be determined during the RO. GW goals are based on SDWA MCLs. Benzene:5 µg/L PCE:5 µg/L TCE:5 µg/L	\$77,000,000 includes: \$11,833,000 (annual O&M costs)
5	Buckeye Reclamation, OH 8/19/91	Soil and GW contaminated with benzene, TCE, toluene, arsenic, chromium, beryllium, and lead	Not specified	Landfill capping; installation of a leachate seep and GW collection system. Wetland treatment of collected wastewaters with surficial discharge; long-term monitoring and institutional controls.	Waiving RCRA closures requirements. No specific goals. Wetlands discharge will not exceed NPDES permit.	\$48,663,000 includes: \$99,000 (annual O&M cost for 30 years)
5	Conrail Railyard Ilkhart, IN 6/28/91	GW contaminated with TCE, carbon tetrachloride	Not specified	Pump and treatment of GW using prefiltration and air stripping; onsite surface water discharge; treatment of air emissions; groundwater monitoring and institutional controls.	Goals not defined - to be addressed during remediation	\$3,969,300 includes: \$125,000 (annual O&M cost for 20 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
4	Robins Air Force Base, GA 6/26/91	Soil and GW contaminated with PCE, TCE, arsenic, chromium, and lead	Not specified for GW 15,000 cubic yards of soil	In-situ soil vapor extraction, condensation, distillation, and carbon adsorption to remove VOCs from the air; treating landfill leachate; onsite pump and treatment of GW; long-term monitoring of soil, GW and surface water.	Goals for both soil and GW will be specified in a subsequent ROD.	\$9,430,000 to \$24,000,000 includes: \$321,400 to \$334,400 (annual O&M cost)
5	Verona Well Field, MI 6/28/91	Soil and GW contaminated with benzene, PCE, TCE, toluene, xylenes, other organics, phenols, arsenic, and chromium.	Not specified	In-situ vapor extraction; continue operation of purge wells and air stripper; onsite air stripping and vapor phase carbon adsorption for GW; onsite discharge to surface water; monitoring all media (including air)	Clean-up goals are based on state standards. Soil: Benzene:20 µg/kg PCE:10 µg/kg TCE:60 µg/kg Toluene:16,000 µg/kg Xylenes:6,000 µg/kg Arsenic:0.4 µg/kg Chromium:2,000 µg/kg GW: Benzene:1 µg/L PCE:0.7 µg/L TCE:3 µg/L Toluene:800 µg/L Xylenes:300 µg/L Arsenic:0.02 µg/L Chromium:100 µg/L	\$15,300,000 includes: \$840,000 (annual O&M for a maximum of 30 years)
4	Mallory Capacitor Company, TN 8/29/91	GW contaminated with 1,2-DCE and TCE; other organics including PCBs	Not specified	GW pump and treat using air stripping; precipitate removal using filtration and carbon adsorption; onsite discharge to surface water or offsite discharge to POTW; GW monitoring; institutional controls	Clean-up goals are based on SDWA MCLs: PCBs:0.5 µg/L TCE:5 µg/L cis-1,2-DCE70 µg/L trans-1,2-DCE100 µg/L	\$3,005,000

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	Main Street Well Field, IN 3/29/91	Soil and GW contaminated with PCE, TCE, xylenes, other organics including PAHs; and arsenic	Not specified for GW; 22,000 cubic feet of soil	In-situ vacuum extraction of soil; soil removal and incineration of paint waste; interceptor wells; pump and treatment of GW using air stripping; GW monitoring; institutional controls.	Performance standards for soil and GW are based on a 10^{-6} excess lifetime cancer risk. Soil: TCE:100 µg/kg PCE:0.6 µg/L TCE:1 µg/L	\$3,370,000 includes: \$130,000 (annual O&M cost for 20 years)
2	Naval Air Engineering Center (Area C), NJ 2/04/91	GW contaminated with benzene, TCE, and xylenes	Not specified	Pump and treatment of GW, followed by offsite disposal of solids and free product; onsite vapor phase carbon adsorption and air stripping; effluent polishing followed by irrigating or infiltrating over onsite soil.	Clean-up goals will be addressed in the final remedy.	\$700,000 includes: \$100,000 (annual O&M cost for 3 years)
9	Castle Air Force Base, CA 8/12/91	GW contaminated with benzene, PCE, and TCE	Not specified	Pump and treatment of GW using air stripping; followed by natural biological enhancement; reinjecting GW to maintain hydraulic control; air stripping emissions will be treated with activated carbon; liquid condensate disposed offsite.	Clean-up goals will be based on MCLs and risk levels and will be addressed in a subsequent ROD.	\$28,445,000 includes: \$2,744,000 (annual O&M cost)
4	Sherwood Medical Industries, FL 3/27/91	GW contaminated with PCE and TCE	Not specified	Installation of recovery wells and pumping and treating of GW using air stripping, followed by onsite discharge to Lake Miller.	Treated GW will meet all federal and state water quality standards for discharge to surface water. Final clean-up levels will be addressed in a future ROD.	Interim action remedy is \$4,000,000 including: \$35,000 (annual O&M) Present worth could not be calculated.
3	Dorney Road Site, PA 9/30/91	GW contaminated with benzene and TCE	Not specified	Wellhead treatment using carbon adsorption for private wells and GW monitoring.	ARAR waivers will be issued for state standards requiring remediation of onsite GW to background levels.	\$274,000 includes: \$14,140 (annual O&M cost)
4	Anniston Army Depot, AL 9/26/91	GW contaminated with PCE and TCE	Not specified	GW pump and treat using air stripping discharge of treated GW onsite to surface water	Clean-up goals will be addressed in the final remedial action for the site.	\$945,000 includes: \$60,000 (annual O&M) estimated capital cost is \$895,000

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
5	National Presto Industries, WI 9/30/91	GW contaminated with PCE, TCA, and TCE	Not specified	Pump and treatment of GW using cascade aeration units; discharge of water to onsite storm sewers; GW monitoring	Chemical-specific clean-up goals will be developed as part of subsequent investigation	\$1,290,000 includes: \$163,000 (annual O&M cost for years 0-1) \$104,000 (annual O&M cost for years 2-30)
5	Fultz Landfill, OH 9/30/91	Soil, sediment, debris, GW, and SW contaminated with benzene, PCE, TCE, toluene, xylenes, PAHs, phenols, arsenic, chromium, and lead	Not specified	Onsite treatment plant and leachate collection system; pump and treat using filtration and carbon adsorption; discharge to onsite surface water; surface water and sediment diversion; alternate drinking water supply; monitoring of all media; institutional controls.	Chemical-specific goals not provided. Upgradient GW will be reduced to background, others will be reduced to SDWA MCLs or to a cumulative carcinogenic less no greater than 10^{-6} or an HI < 1.	\$19,480,700 includes: \$218,000 (annual O&M cost for 30 years)
3	Havertown PCP Site, PA 9/30/91	GW contaminated with benzene, TCE, toluene, xylenes, dioxin, oils, PCP, phenols, arsenic	Not specified	Powdered activated carbon treatment or an advanced oxidation process and granule activated carbon treatment; discharge to onsite surface water; treat and dispose of residuals offsite; GW monitoring	Based on background levels, the more stringent of SDWA MCLs or MCLGs or new limits set forth in the final remedial action.	\$10,036,000 to \$12,177,000 includes: \$485,500 to \$595,000 (annual O&M cost for 30 years)
5	Pine Bend San Landfill, MN 9/30/91	Site contaminated with benzene, PCE, TCE, and toluene	Not specified	Alternative water supply; permanently sealing the potentially affected onsite private water supply wells.	Not applicable	\$2,649,499 includes: \$30,350 (annual O&M cost for 30 years)
1	Western Sand and Gravel, RI 4/16/91	GW contaminated with benzene, PCE, TCE, toluene, vinyl chloride, xylenes, arsenic, chromium, and lead	Not specified	Natural attenuation of GW; site monitoring for sediment, GW and SW; institutional controls; alternate contingency scenarios if selected remedy does not attain goals.	Interim GW clean-up goals are based on SDWA MCLs and MCLGs a 10^{-6} excess cancer risk and an HI = 1 or PQLs. Benzene:5 µg/L PCE:5 µg/L TCE:5 µg/L Toluene:1 mg/L Vinyl chloride:2 µg/L Xylenes:10 mg/L Lead:5 µg/L	Not stated

Table A-3 (Cont.)
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
3	Strasburg Landfill, PA 6/28/91	Site contaminated with benzene, PCE, TCE, toluene, arsenic, and chromium	Not specified	Site access restrictions	Not applicable	\$823,020 includes: \$55,405 (annual O&M costs)
3	Old City of York Landfill, PA 9/30/91	GW contaminated with benzene, PCE, and TCE	Not specified	Restoring and revegetating the soil cover, disposing of vault sediment offsite; installing a diversion swale; air stripping with onsite discharge to surface water, landfill gas venting with monitoring probes; access restrictions; monitoring of GW, SW, and sediment.	Remediation will continue until contaminant levels meet the lower of site background levels and federal and state standards. No chemical specific standards provided.	\$8,291,080 includes: \$259,080 (annual O&M cost for 30 years)
5	Lemberger Transport and Recycling Inc., WI 8/23/91	GW contaminated with PCE, TCE, toluene, xylenes, PCBs/pesticides, arsenic, chromium, and lead	Not specified	Granular activated carbon; blending water extracted from slurry wall with GW extracted for remediation; discharge effluent to Branch River; provide an alternate water supply; GW monitoring; institutional controls	Most stringent of state standards, SDWA, MCLs, and risk-based levels. PCE:0.1 µg/L TCE:0.18 µg/L Toluene:68.6 µg/L Xylenes:124 µg/L	\$19,200,000 includes: \$731,000 (source control remedy and annual O&M cost for years 0-1) \$596,000 (source control remedy and annual O&M cost for years 2-30)
3	William Dick Lagoons, PA 6/28/91	GW contaminated with benzene, PCE, TCE, phenol, and metals	30 to 40 private wells known to have TCE contamination	Alternate water supply; GW monitoring; pump and treatment of onsite GW plume; pond site discharge to surface water; institutional controls	EPA is invoking a waiver for federal and state GW cleanup standards because the remedial action is an interim measure. Chemical-specific goals will be set in the final remedy.	\$5,991,000 to \$7,029,000 includes: \$305,000 to \$330,000 (annual O&M cost for years 0-5) \$21,000 to \$46,000 (annual O&M cost for years 6-30)
2	Endicott Village Well Field Endicott, NY 3/29/91	VOCs including benzene, PCE, and TCE	Not specified	Upgrading the existing purge well system by installing an additional purge well between the landfill and the Ranney well; pumping GW from the purge well and discharging the water onsite to the sewage treatment plant, or treating the water prior to discharge, based on results of purge well testing; monitoring purge wells water.	Not provided.	\$376,000 (present worth) \$24,000 (annual O&M 0-30 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
9	Teledyne Semiconductor Mountain View, CA 3/22/91	VOCs including PCE, TCE, toluene, and xylenes	1962-1980 1,400 gal (2 each) underground sumps (acid neut. and waste TCE) 2,000 gallon waste solvent tank (liquid chem wastes) Spectra-physics site: volumes not specified	Soil vapor extraction for soil clean-up; GW extraction and treatment for GW clean-up; shallow zone, intermediate zone, and deep aquifer GW monitoring; soil monitoring	<u>Soil:</u> To meet state standards and reduce the risk of additional GW contamination PCE:5 µg/kg (state) TCE:5 µg/kg (state) Toluene:100 µg/kg (state) <u>GW:</u> To meet state and federal MCLs or MCLGs PCE:5 µg/L (MCL) TCE:5 µg/L (MCL) Toluene:100 µg/L (state)	<u>Total:</u> \$19,226,352 (present cost) \$909,425 (annual O&M) (0-30 years) <u>Teledyne:</u> \$2,000,000 (present worth) \$86,000 (annual O&M) (6-30 years) <u>Spectra Physics:</u> \$2,729, 595 (present worth) \$188,600 (annual O&M) <u>Mountain View Area</u> (offsite) \$10,496,757 (present worth) \$720,739 (annual O&M) (0-30 years)
8	Chemical Sales, CO 6/27/91	VOC including benzene, PCE, and TCE	Not specified	Control of migration of contaminated GW from OU 1 into OU 2 (separate ROD prepared of OU 1) OU 2 Remediation: Extraction of contaminated GW; air stripping of GW; reinjection; monitoring of GW continued capture and treatment. Voluntary abandonment of bedrock wells	GW goals based on SDWA MCLs, include: Benzene:5 µg/L (MCL) PCE:5 µg/L (MCL) TCE:5 µg/L (MCL)	\$2,420,000 (present worth) \$223,000 (annual O&M) (0-8 years) \$27,000 (annual O&M) (8-20 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
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Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Rockaway Boro Wellfield Rockaway, NJ 9/30/91	VOCs including PCE, TCE, metals: Chromium and lead	Not specified	Onsite pumping and treatment of GW using chemical precipitation and air stripping, followed by reinjection of the treated GW onsite into the glacial aquifer; conducting environmental monitoring	Chemical-specific GW clean-up goals based on more stringent of federal or state MCLs, PCE:1 µg/L (state MCL) TCE:1 µg/L (state MCL)	\$17,818,000 (present worth) \$1,502,000 (annual O&M) (0-27 years)
3	Greenwood Chemical Company, VA 12/31/90	GW and SW contaminated with benzene, PCE, TCE, toluene, naphthalene, and arsenic	Not specified	Pump and treatment of GW and SW using precipitation, sedimentation, filtration, and UV/oxidation; discharge to onsite SW.	Interim action: none provided	\$3,218,000 includes: \$1,419,000 (estimated O&M cost for 5 years)
5	Washington County Landfill, MN	GW contaminated with benzene, PCE, TCE, and xylenes	2.57 million cubic yards of solid waste were disposed in the landfill.	Provide alternate drinking water supply; continued operation of gradient control well and spray-irrigation treatment system; onsite discharge to surface water.	Based on RALS established by the state Benzene:7 µg/L PCE:6.6 µg/L TCE:31 µg/L Xylenes:400 µg/L	\$400,000 includes: \$2,469 (annual O&M cost)
2	Applied Environmental Services, Glenwood Landing, NY 6/24/91	VOCs, TCE, Toluene, Xylenes, PCBs, PAHs, Metals: Arsenic, chromium, and lead	1978 3,000 gallons toluene spill 410 drums hazardous waste (255 of these removed in 1984) Others not specified	Active venting, by vacuum extraction, of contaminated unsaturated soils; collection of contaminated groundwater from a series of shallow GW extraction wells; treatment of the collected GW by air-stripping reinjection of treated GW along with nutrients and a chemical source of oxygen to stimulate the growth of indigenous bacteria capable of degrading contaminants in the GW and saturated soils; treatment (e.g. catalytic oxidation) of contaminant laden vapors from the vacuum extraction and air stripping processes before release to the atmosphere.	<u>Soil:</u> Based on risk-based criteria <u>GW:</u> Based on state standards Chemical-specific standards: Arsenic:25 µg/L Chromium:50 µg/L Lead:25 µg/L TCE:5 µg/L Toluene:5 µg/L Xylenes:15 µg/L <u>Other Media:</u> Based on applicable standards for sediment, surface water, and air	\$4,507,000 (present worth) \$970,000 (annual O&M) (0-4 years)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1991

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
3	NCR Corp., Millsboro Millsboro, DE 8/12/91	VOCs: TCE Metals: Chromium	Not specified	Extraction of contaminated GW until clean-up levels are achieved; treatment of VOC contamination in GW using an airstripper followed by carbon absorption of the effluent until the clean-up levels (MCLs and non-zero MCLs) are achieved; a provision for air emissions controls, if determined necessary by EPA, during predesign studies; a combined discharge to surface water and/or onsite GW infiltration galleries. Continued quarterly monitoring of groundwater until the clean-up levels (MCLs and non-zero MCLs) are achieved; a provision for air emissions controls, if determined necessary by EPA, during predesign studies; a combined discharge to surface water and/or onsite GW infiltration galleries. Continued quarterly monitoring of groundwater until the clean-up levels (MCLs and non-zero MCLGs) are achieved; instituting an annual monitoring program for surface water and sediments of iron branch until the clean-up levels (MCLs and non-zero MCLs) are achieved; institutional controls.	Based on SDWA MCLs and non-zero MCLGs, include: TCE:5 µg/L (MCL) Chromium:100 µg/L (MCL) Discharge limitations: SDWA MCLs Non-zero MCLGs SWDW a underground injection control limits; CWA-NPDES; CWA-AWQC; and state requirements.	\$4,749,000 (present worth) \$859,000 (annual O&M)

Table A-3 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1991

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Genzale Plating Company, NY 3/29/91	GW and soil contaminated with PCE, TCE, PAHs, arsenic, chromium, and lead	Not specified	In-situ vacuum extraction of soils and vapor phase carbon adsorption; excavation of treated soil and top soil and material from the leach pits; offsite treatment and disposal pump and treat of GW using air stripping with onsite reinjection and offsite disposal of treatment residuals.	Soil: TCE:1 mg/kg GW: Not discussed for organics	\$6,358,700 includes: \$223,800 (annual O&M cost)
3	Delta Quarries Stotlen Landfill, PA 3/29/91	GW contaminated with PCE, TCE, vinyl chloride, and manganese	Not specified	Pump and treatment of GW using air stripping; offsite surface water discharge; activated carbon to control air emissions; GW and SW monitoring; gas venting system in landfill cap; institutional controls.	Based on more stringent of SDWA MCLs or background levels. 1,2-DCA:5 µg/L cis-1,2-DCE:70 µg/L trans-1,2-DCE:100 µg/L Chloroform:100 mg/L PCE:5 µg/L TCE:5 µg/L Vinyl Chloride:2 µg/L	\$2,344,581 includes: \$1,176,989 (O&M cost over 30 years)
3	Hellertown Manufacturing Company, PA 9/30/91	Soil and GW contamination of benzene, DCE, PCE, TCE, vinyl chloride, xylenes, PAHs, and chromium	Not specified	Capping the lagoon; pump and treatment of GW using air stripping, settling tank or clarifier followed by filtration for solids removal; onsite surface water discharge of effluent; GW monitoring; SW runoff control; institutional controls.	Based on the more stringent of SDWA MCLs or state background concentrations: Benzene:0.2 µg/L PCE:0.03 µg/L TCE:0.12 µg/L Vinyl Chloride:0.18 µg/L	\$2,250,000

Table A-4
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
7	29th & Mead Site Coleman OU, KS 09/29/92	Groundwater, soil, and surface water contaminated with 1,1-DCA, 1,1-DCE, TCE, PCE, and 1,2-DCE		Soil vapor extraction and air monitoring		\$464,000 (O&M) \$1,638,456 (present worth)
5	American Chemical Service, IN 09/30/92	Drums, surface water, groundwater, and soil contaminated with VOCs, PCBs, lead, and SVOCs		<i>In situ</i> vapor extraction of soils and low temperature thermal treatment. Groundwater pump and treat, discharge to surface water and wetlands. Excavation.	10 ppm PCB cleanup action level (40 CFR 761.125(c)(4)(v))	\$46,800,000 (present worth)
1	Brunswick Naval Air Station, ME 6/16/92	DCE, vinyl chloride, methylchloride	16 million gallons	Slurry wall to divert clean GW from the site	MCLs	\$7,842,000 (O&M included)
1	Brunswick Naval Air Station, ME 6/16/92 Eastern Plume	DCE, vinyl chloride, methylchloride	Unknown	Eastern plume wells positioned to hydraulically control eastern plume, pump and treat groundwater	ARARs	\$4,223,000 \$1,845,000 (O&M)
5	Buttenworth Landfill Site, MI 9/29/92	PCB, 1,1-DCE	Unknown	Institution controls, grading and leveling, cap, alternate concentration limits of GW and SRW sediments, continually monitoring	5-year review. If toxic condition is still present, establish site specific concentration limits.	\$13,530,000
3	Butz Landfill, PA 06/30/92	Groundwater, soil, sediment, and surface water contaminated with DNAPLs, TCE, arsenic, beryllium, and mercury		Groundwater extraction and treatment, drill new wells, construct storage tank with a closed-end distribution system. EPA supplies bottled water and carbon-filtration systems maintenance to residents of the affected area. Quarterly sampling.	Remedy will achieve background levels in groundwater for VOCs. Discharge regulations will be met for extracted groundwater.	\$14,995,000 (present worth)

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
8	Chemical Sales (OU4), CO 12/29/92	Groundwater contaminated with DCA, DCE, TCA, TCE, 1,2-DCE, PCE, benzene, and vinyl chloride		Granular activated carbon treatment of groundwater with possible air stripping for vinyl chloride	To below MCLs	\$2,301,800 (capital) \$865,500 (O&M) \$3,314,900 (present worth)
5	City Disposal Corp. Landfill, WI 09/28/92	Groundwater and landfill waste contaminated with VOCs and metals		Twice a year sampling of residential wells for TAL and TCL plus THF. Landfill cover, <i>in situ</i> vapor extraction in the landfill, and gas venting and treatment. Groundwater extraction and treatment by onsite chemical oxidation. Groundwater use restrictions.		\$5,187,066 (capital) \$436,291 (O&M) \$14,851,387 (present worth)
5	Clare Water Supply, MI 09/16/92	Soil and groundwater contaminated with VOCs		Groundwater extraction and treatment by UV photochemical oxidation, SVE	Act 307 Type B soil criteria Toluene 16,000 ppb, ethylbenzene 1,400 ppb, total xylenes 1,000 ppb. Restore groundwater to drinking water use	\$4,461,686 (capital) \$431,183 (O&M) \$11,754,247 (present worth)
2	Cosden Chemical Coatings, NJ 09/30/92	Soil, structure, and groundwater contaminated with VOCs, PAHs, PCBs, metals, asbestos	8,000 yds ³	<i>In situ</i> stabilization of soil. Groundwater extraction with onsite treatment and recharge to aquifer	Site-specific risk-based cleanup levels for soil and groundwater	\$6,126,600 (capital) \$585,500 (O&M) \$15,172,800 (present worth)
7	Des Moines TCE Site (OU3), IA 09/18/92	Groundwater contaminated with TCE, DCE, TCA, and PCE		Continued monitoring. Groundwater extraction and treatment in OU1		No Action
3	Dover AFB, DE Interim Remedial Action 11/04/92	Groundwater and soil contaminated with VOCs	Unknown volume of floating waste	Pumping or bailing to recover and control floating waste.		\$400,000 (present worth)
2	Dover Municipal Well No. 4, NJ 09/30/92	Groundwater contaminated with PCE, TCE, TCA, and DCE		Wellhead extraction, air stripping, discharge to public water supply system	Restore groundwater to MCLs	\$1,985,000 (present worth)

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Ellis Property, NJ 09/30/92	Soil and groundwater contaminated with arsenic, lead, PCBs, BNAs, antimony, beryllium, 1,2-DCE, methylene chloride, nickel, PCE, TCE, 1,1,2-TCA, chromium		Extraction wells and interceptor trench, pump and treat followed by reinjection, excavation of contaminated soils and offsite treatment/ disposal.	Cleanup soil and groundwater to levels specified in <i>Proposed Cleanup Standards for Contaminated Sites</i> (February 1992)	\$1,900,000 (capital) \$479,400 (O&M) \$6,653,000 (present worth)
2	Endicott Village Well Field, NY 09/30/92	Groundwater and soil contaminated with VOCs		Installed water treatment facility will include air stripping and disinfection. Continue operation of existing purge well.	Groundwater will be treated to MCLs	\$12,833,100 (capital) \$258,900 (O&M) \$16,900,000 (present worth)
6	Gulf Coast Vacuum SVS (OU1), LA Final Source Action 09/30/92	Pit sludges, soils, sediment, and groundwater contaminated with arsenic, barium, benzene, PAHs, and dioxins	3,000 yds ³	Onsite incineration of pit sludges, soils, and tank contents. Institutional controls and long-term groundwater monitoring.	Health-based performance standards to fall within target cancer risk range of 10 ⁻⁴ to 10 ⁻⁶ and hazard index should be less than 1.	\$13,026,000 (present worth)
2	Higgins Farm, NJ 09/30/92	Groundwater contaminated with VOCs and metals		Groundwater extraction wells, onsite treatment, discharge to onsite surface water.	Groundwater to be treated to MCLs, if possible	\$2,544,800 (capital) \$384,000 (O&M) \$8,447,600 (present worth)
1 WHICH DO	Holton Circle Groundwater Contamination, NH 09/30/92	Groundwater contaminated with VOCs, 1,1-DCE, 1,1-DCA, metals, SVOCs				
YOU WANT 1	Holton Circle GW Contamination, NH 9/30/92	PCE, TCE, 1,1,1-TCA, DCE, DCA, carbon tetrachloride	Unknown	Natural attenuation, institution controls, GW monitoring, alternate water supply	7-25 years for all MCLs to be reached	\$1,246,000

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
2	Imperial Oil/Champion Chemicals, NJ 09/30/92	Groundwater contaminated with metals, PCBs, organics		Groundwater extraction, treatment of organics via carbon adsorption, discharge to surface water, floating product removal, monitoring	MCLs or health-based values where MCLs are not available	\$1,526,000 (capital) \$515,000 (O&M) \$9,647,000 (present worth)
2	Islip Sanitary Landfill, NY 09/30/92	Soil and groundwater contaminated with VOCs and inorganics		Installation of a geosynthetic cap for the landfill, runoff control, extract and treat groundwater, discharge to onsite recharge basin.	Treat only groundwater >50 ppb total VOCs. Return to drinking water quality with extraction/treatment and natural attenuation.	\$13,353,150 (capital) \$4,588,875 (O&M) \$17,942,025 (present worth)
9	Lawrence Livermore National Laboratory, CA 08/05/92	Groundwater and sediments contaminated with VOCs, FHCs, chromium, lead	200 gallons of undiluted VOCs	Groundwater extraction with treatment via UV oxidation. Vacuum-induced venting of the contaminated sediments and surface treatment of vapors by catalytic oxidation.	Below MCLs in groundwater.	\$103,000,000 (present worth)
5	Muskego Sanitary Landfill, WI Interim Action OU Remedy 06/12/92	Groundwater and soil contaminated with organics, semivolatile organics, PCBs, metals		Deed restrictions and site controls, cap installation, upgrade or install landfill leachate control systems, landfill gas control, <i>in situ</i> SVE, groundwater monitoring.	Minimize migration from soil/refuse to groundwater that would cause groundwater concentrations to exceed MCLs, ESSs, or PALs.	\$7,984,000 (capital) \$9,914,000 (O&M) \$_____ (present worth)
5	New Brighton/TCAAP (OU3), MN 09/30/92	Groundwater contaminated with TCE, DCE, TCA, and DCA		Groundwater extraction and treatment via pressurized GAC, discharge to potable water supply, groundwater monitoring.		\$2,249,000 (capital) \$276,000 (O&M) \$4,851,000 (present worth)

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
1	PSC Resources, MA Waste Lagoon 9/15/92	Chlorinated HC, TCA, TCE, PCE, ketones, BTEX	Unknown	Natural attenuation, GW monitoring, institutional controls, 5-year site reviews.	Reduce to MCLs in 4 to 11 years	\$353,701 (Groundwater monitoring institutional controls only)
2	Pasley Solvents & Chemical, NY 04/24/92	Groundwater and soil contaminated with VOCs, SVOCs	13,000 yds ³ of soil	Soil vacuuming and/or soil flushing, disposal at a RCRA facility. Groundwater extraction and treatment via metals precipitation, air stripping with vapor-phase GAC, GAC polishing and recharge, long-term monitoring.	MCLs may not be possible due to upgradient source of contamination	\$5,201,000 (capital) \$1,336,000 (O&M) \$13,744,000 (present worth)
2	Plattsburgh AFB (OU3), NY Selected source control remedial action 09/30/92	Soil and groundwater contaminated with VOCs, PHCs, pesticides, and metals		Grading and vegetation establishment, control rainwater runoff, and minimize erosion.	No specified cleanup levels in soil	\$1,200,000 (capital) \$92,000 (O&M) \$2,100,000 (present worth)
2	Plattsburgh AFB (OU1), NY 09/30/92	Groundwater, surface water, and sediment contaminated with VOCs, SVOCs, PHCs, metals, and pesticides.		Institutional controls, low-permeability barrier cover for landfill, inspection, maintenance, and monitoring. Groundwater, surface water, and sediment addressed in separate ROD.	No specified cleanup levels in soil.	\$3,600,000 (capital) \$105,000 (O&M) \$4,600,000 (present worth)
6	Prewitt Abandoned Revinery, NM 09/30/92	Soil, groundwater, and sludge, contaminated with lead, asbestos, NAPLs, PAHs, BTEX, DCA, and benzo(a)pyrene.				\$7,053,872 (capital) \$1,097,844 (O&M) \$16,301,576 (present worth)
9	Purity Oil Sales, CA Final Action 09/30/92	Soil contaminated with lead, pesticides, benzene, toluene, PAHs, methylene chloride, phthalates, acetone, and solvents	6.8 acres to cap, >71,000 lbs of total VOCs in top 12 feet of soil.	RCRA equivalent cap, SVE system and slurry cut-off wall, 14-40 feet depth soil treatment, environmental monitoring.	MCLs in groundwater	\$17,023,000 (capital) \$736,000 (O&M) \$36,254,000 (present worth)

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
4	Redwing Carriers Inc., AL Final Remedial Action 12/15/92	Sludge, sediments, soil, and groundwater contaminated with pesticides, herbicides, VOCs, and PAHs.	12 million gallons of surficial water	Excavation of sludge, sediments, and soils with offsite treatment and disposal. Relocation of residents. Extraction, onsite treatment, and discharge to the POTW or nearby surface water body of surficial groundwater. Active treatment of alluvial groundwater will occur if natural attenuation does not progress at an appropriate rate.	<p>Surface soil and sediment excavation levels:</p> <p>Benzo(a)pyrene 94.9 µg/kg Benzo(b)fluoranthene 540 µg/kg Benzo(a)anthracene 1,025 µg/kg Carbon tetrachloride 9,590 µg/kg Chrysene 362 µg/kg</p> <p>Subsurface soil excavation levels:</p> <p>4,4'-DDT 566 µg/kg Acetone 36 µg/kg Aldrin 4 µg/kg Alpha-BHC 0.5 µg/kg Chloroform 70 µg/kg Chromium 47,000 µg/kg Dieldrin 0.1 µg/kg Gamma-BHC 3.2 µg/kg Methylene chloride 0.6 µg/kg Nickel 30,000 µg/kg Vanadium 156,000 µg/kg Vernolate 55 µg/kg</p>	\$7,002,562 (present worth)

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

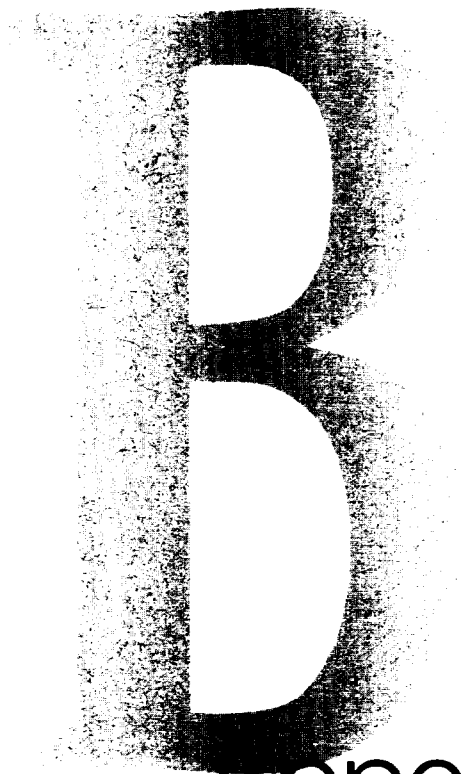
Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
	Redwing Carriers (Cont.)				<p>All health-based levels to result in a 10^{-6} risk at completion.</p> <p>Groundwater cleanup levels at compliance points:*</p> <p>4,4'-DDT 0.158 µg/L</p> <p>Acetone 1,120 µg/L</p> <p>Aldrin 0.00317 µg/L</p> <p>Alpha-BHC 0.00855 µg/L</p> <p>Beryllium 4.00 µg/L</p> <p>Bis(2-ethylhexyl)phthalate 6.00 µg/L</p> <p>Carbon disulfide 47.6 µg/L</p> <p>Chloroform 100 µg/L</p> <p>Chromium 50 µg/L</p> <p>Dieldrin 0.00337 µg/L</p> <p>Gamma-BHC 0.2 µg/L</p> <p>Methylene chloride 5 µg/L</p> <p>Nickel 100 µg/L</p> <p>Vanadium 78.1 µg/L</p> <p>Vernolate 11.2 µg/L</p> <p>* Based on MCL or Risk Assessment</p>	
1	Revere Textile Prints Corp., CT 09/30/92	Soils contaminated with VOCs, PAHs, and metals		Five years of monitoring of groundwater and sediments.		No Action
8	Rocky Flats Plant (OU2), CO (IM/IRAP/EA) 08/20/92	Groundwater, soil, surface water, and air contaminated with VOCs, metals, and radionuclides.		<i>In situ</i> vacuum-enhanced vapor extraction and dewatering, surface water treatment includes precipitation/microfiltration, and GAC adsorption units. Investigation-generated wastewater will be treated by GAC adsorption system, precipitation/vacuum filtration and evaporation.	Aid in design of final remedies	

Table A-4 (Cont.)
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford Site
Fiscal Year 1992

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
3	Route 940 Drum Dump Site, PA 09/28/92	Soil and groundwater contaminated with VOCs, metals, and pesticides.		Future groundwater monitoring		No Action
2	Rowe Industries, NY 09/30/92	Groundwater and soil contaminated with VOCs	365 yds ³ of soil	Excavation and disposal of soil with confirmatory sampling. Pump and treat (air stripping) with discharge to Sag Harbor Cove. System monitoring.	Meet federal and state MCLs in the aquifer.	\$2,280,000 (capital) \$254,000 (O&M) \$6,187,000 (present worth)
1	Tibbetts Road, NH 09/29/92	Groundwater contaminated with VOCs and SVOCs		Upgrade and expand water supply system, capture groundwater through trenches and wells, UV oxidation of groundwater, dewatering and vacuum extraction, institutional controls on groundwater use, long-term monitoring, five-year reviews, security fence, and removal of debris.	Interim cleanup levels based on MCLs or nonzero MCLGs. 15 ppb action level for lead in particulate form.	\$1,728,690 (capital) \$2,046,970 (O&M) \$3,775,660 (present worth)
5	Tri-County Elgin-Landfill, IL 9/30/92	TCE, benzene, vinyl chloride	Unknown	Slurry wall to prevent uncontaminated water from flowing into the site.	MCLs with a 5-year evaluation to determine if hazardous conditions still exist.	\$12,624,000
5	Twin Cities Air Force Reserve SAR Landfill, MN 3/31/92	Benzene, toluene, TCE, metals	Unknown	Natural attenuation, access restriction, GW/SW monitoring	Below MCLs	\$737,000 (including \$684,000 for O&M)
2	Witco Chemical Corp., NJ 09/28/92	Soil and groundwater with VOCs.				No Action \$8,660 (present worth)

Table A-5
Record of Decision (ROD) Summary Table — Relevant to the Southeast Rockford site
Fiscal Year 1993

Region	Site Name, State, Type, Signature, Date, Remedial Action	Threat/Problem	Waste Volume	Components of Selected Remedy	Cleanup Goals	Present Worth/Capital and O&M Costs
10	Craig Landfill/Fairchild AFB, WA 02/11/93	Groundwater and soil contaminated with TCE, DCE, vinyl chloride, and BEHP		Soil vapor extraction, capping, groundwater extraction and treatment via air stripping with carbon treatment of off-gas.		\$6,554,375 (capital) \$395,500 (O&M) \$12,634,180 (present worth)
9	Defense Distribution Region, CA 01/25/93	Groundwater contaminated with VOCs, arsenic, selenium, nitrate, and bromacil				\$2,007,000 (capital) \$2,140,000 (O&M) \$4,147,000 (present worth)
3	Ohio River Park (OU2) PA 03/31/93	Soil contaminated with VOCs, SVOCs, and inorganics				No Action
6	Popple, Inc. Site, AR 02/01/93	Groundwater and soil contaminated with NAPLs, DNAPLs, PCBs, creosote, VOCs, and PAHs.				\$12,700,000 (capital) \$178,000 (O&M) \$17,700,000 (present worth)
7	Red Oak Landfill, IA 03/30/93	Soils and groundwater contaminated with VOCs, heavy metals, PAHs, and SVOCs		Construction of low permeability cap, groundwater monitoring, stabilize river bank slope, and institutional controls.	Limit the potential for exposure through direct contact.	\$1,695,100 (capital) \$735,100 (O&M) \$3,150,200 (present worth)
3	Saegertown Industrial Area, PA 01/29/93	Soil, groundwater, and sludge contaminated with PCBs, PAHs, and metals.		Incineration of sludge and soil, air sparging, and pump and treat for groundwater.	Restore groundwater to background, but may default to MCLs if not practicable.	\$13,510,000 (capital) \$275,000 (O&M) \$15,100,000 (present worth)
9	San Gabriel Valley, CA Areas 1-4, Whittier Narrows OU 03/31/93	Groundwater and surface water contaminated with volatile organics, TCE, and PCE.				No Action (monitoring only)



Appendix B

Appendix B

Cost Estimating

Camp Dresser & McKee Inc.

BY: T. Mercer

DATE: 05/04/95

CLIENT: IL-EPA

PROJECT: SE Rockford, IL

JOB #: 1681-007-FS-FSANL

SCREENING OF ALTERNATIVES COST ESTIMATING WORKSHEET (+50% TO -30% Level)

CHK BY: SER

DATE: 05/04/95

Current ENR Construction Cost Index:

5300

ITEM: ALTERNATIVE 1 - No Action

DESCRIPTION: Source control & monitoring of new and existing wells.

DIRECT CAPITAL COSTS

(Includes Labor, Equipment & Materials, Unless Otherwise Noted)

	COST COMPONENT	UNIT	QUANTITY	UNIT COST	TOTAL CAPITAL COST	COST SOURCE
1.						
	a. Source Control(included under separate OU)	EA	0	\$0	\$0	
	b. Monitoring Locations(2 wells/location)	EA	5	\$5,000	\$25,000	G.M. FS
TOTAL DIRECT COSTS					\$25,000	

INDIRECT CAPITAL COSTS (% of Direct Capital Costs)

1. Engineering & Design 15% of Direct Capital	\$4,000
2. Contingency Allowance 15% of Direct Capital	\$4,000
3. Other Indirect Costs	
A. Legal Fees 1%	\$0
B. Regulatory License/permits Costs 5%	\$1,000
TOTAL INDIRECT CAPITAL COSTS	\$9,000

TOTAL CAPITAL COSTS \$34,000 (Rounded)

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

ITEM: ALTERNATIVE 1 - No Action

ANNUAL/PERIODIC (O & M) COSTS

ANNUAL/PERIODIC (O & M) COSTS							PRESENT	WORTH	Discount Rate	5.00%
COST COMPONENT	UNIT	FREQUENCY	QUANTITY PER YEAR	UNIT COST	ANNUAL COST	LIFE OF ITEM (YEARS)	ANNUAL COST	PERIODIC COST	COST SOURCE	
DIRECT ANNUAL/PERIODIC COSTS:										
1.										
a. Source Control(included under separate OU)	LS	Annual	0	\$0	\$0	205	\$0	n/a		
b. GW Monitoring	LS	Quarterly	140	\$300	\$42,000	205	\$840,000	n/a	TCB	
c. Remedy as necessary	LS	Annual	1	\$1,500	\$1,500	205	\$30,000	n/a	G.M. FS	
TOTAL DIRECT ANNUAL/PERIODIC COSTS (Rounded):					\$44,000					
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$870,000	\$0		
INDIRECT ANNUAL/PERIODIC COSTS (% of Direct Annual/Periodic Costs):										
Administration (5%)	LS	Annual	1	\$2,200	\$2,200	205	\$44,000	n/a		
Insurance, Taxes and Licenses (5%)	LS	Annual	1	\$2,200	\$2,200	205	\$44,000	n/a		
Maintenance Reserve & Contingency Costs (15%)	LS	Annual	1	\$6,600	\$6,600	205	\$132,000	n/a		
TOTAL INDIRECT ANNUAL/PERIODIC COSTS:					\$11,000					
TOTAL INDIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$220,000	\$0		
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$870,000	\$0		
TOTAL ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$1,090,000	\$0		
TOTAL DIRECT COST					\$25,000					
TOTAL INDIRECT CAPITAL COSTS					\$9,000					
TOTAL ANNUAL/PERIODIC COSTS (DIRECT +INDIRECT)					\$1,090,000					
TOTAL PRESENT WORTH (CAPITAL + ANNUAL/PERIODIC COSTS):					\$1,124,000					

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

SCREENING OF ALTERNATIVES COST ESTIMATING WORKSHEET (+50% TO -30% Level)

Current ENR Construction Cost Index: 5300

ITEM: ALTERNATIVE 2A - Limited Action, Institutional Controls

DESCRIPTION: Source control, monitoring of new and existing wells and institutional controls.

DIRECT CAPITAL COSTS

(Includes Labor, Equipment & Materials, Unless Otherwise Noted)

	COST COMPONENT	UNIT	QUANTITY	UNIT COST	TOTAL CAPITAL COST	COST SOURCE
1.						
	a. Source Control(included under separate OU)	EA	0	\$0	\$0	
	b. Monitoring Locations(2 wells/location)	EA	5	\$5,000	\$25,000	G.M. FS
2.	Institutional Controls					
	a. City Water Mains	LF	21000	\$50	\$1,058,000	1990 CDM 8" Steel Pipe (update from CCI @ 4732)
	b. City Water Service Connections	EA	400	\$1,000	\$400,000	

TOTAL DIRECT COSTS \$1,483,000

INDIRECT CAPITAL COSTS (% of Direct Capital Costs)

1.	Engineering & Design 15% of Direct Capital	\$222,000
2.	Contingency Allowance 15% of Direct Capital	\$222,000
3.	Other Indirect Costs	
	A. Legal Fees 1%	\$15,000
	B. Regulatory License/permits Costs 5%	\$74,000

TOTAL INDIRECT CAPITAL COSTS \$533,000

TOTAL CAPITAL COSTS \$2,016,000 (Rounded)

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

ITEM: ALTERNATIVE 2A - Limited Action, Institutional Controls

							PRESENT	WORTH	Discount Rate	5.00%
ANNUAL/PERIODIC (O & M) COSTS										
COST COMPONENT	UNIT	FREQUENC	QUANTITY PER YEAR	UNIT COST	ANNUAL COST	LIFE OF ITEM (YEARS)	ANNUAL COST	PERIODIC COST	COST SOURCE	
DIRECT ANNUAL/PERIODIC COSTS:										
1.										
a. Source Control(included under separate OU)	LS	Annual	0	\$0	\$0	205	\$0	n/a		
b. GW Monitoring	LS	Quarterly	140	\$300	\$42,000	205	\$840,000	n/a	TCB	
c. Remedy as necessary	LS	Annual	1	\$1,500	\$1,500	205	\$30,000	n/a	G.M. FS	
2. Institutional Controls										
a. Public Education Programs	LS	Monthly	12	\$700	\$8,400	205	\$168,000	n/a	G.M. FS	
b. City Water Mains	LS	Annual	0	\$0	\$0	205	\$0	n/a	Turn over mains to city	
c. City Water Service Connections	EA	Annual	0	\$0	\$0	205	\$0	n/a	Turn over mains to city	
TOTAL DIRECT ANNUAL/PERIODIC COSTS (Rounded):					\$52,000					
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$1,038,000	\$0		
INDIRECT ANNUAL/PERIODIC COSTS (% of Direct Annual/Periodic Costs):										
Administration (5%)	LS	Annual	1	\$2,600	\$2,600	205	\$52,000	n/a		
Insurance, Taxes and Licenses (5%)	LS	Annual	1	\$2,600	\$2,600	205	\$52,000	n/a		
Maintenance Reserve & Contingency Costs (15%)	LS	Annual	1	\$7,800	\$7,800	205	\$156,000	n/a		
TOTAL INDIRECT ANNUAL/PERIODIC COSTS:					\$13,000					
TOTAL INDIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$260,000	\$0		
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$1,038,000	\$0		
TOTAL ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$1,298,000	\$0		
TOTAL DIRECT COST					\$1,483,000					
TOTAL INDIRECT CAPITAL COSTS					\$533,000					
TOTAL ANNUAL/PERIODIC COSTS (DIRECT +INDIRECT)					\$1,298,000					
TOTAL PRESENT WORTH (CAPITAL + ANNUAL/PERIODIC COSTS):					\$3,314,000					

Camp Dresser & McKee Inc.

BY: T. Mercer

DATE: 02/02/95

CLIENT: IL-EPA

PROJECT: SE Rockford, IL

JOB #: 1681-007-FS-FSANL

SCREENING OF ALTERNATIVES COST ESTIMATING WORKSHEET (+50% TO -30% Level)

CHK BY: SER

DATE: 05/04/95

Current ENR Construction Cost Index:

5300

ITEM: ALTERNATIVE 2B - Limited Action, Limited Pumping with Natural Attenuation

DESCRIPTION: Source control, monitoring of new and existing wells, institutional controls, extraction wells at node PW4, connecting piping, equalization basin and air stripper. Treated water discharged to city storm sewer system, natural attenuation.

DIRECT CAPITAL COSTS

(Includes Labor, Equipment & Materials, Unless Otherwise Noted)

COST COMPONENT	UNIT	QUANTITY	UNIT COST	TOTAL CAPITAL COST	COST SOURCE
1.					
a. Source Control(included under separate OU)	EA	0	\$0	\$0	
b. Monitoring Locations(2 wells/location)	EA	5	\$5,000	\$25,000	G.M. FS
2. Institutional Controls					
a. City Water Mains	LF	21000	\$50	\$1,058,000	1990 CDM 8" Steel Pipe (update from CCI @ 4732)
b. City Water Service Connections	EA	400	\$1,000	\$400,000	
3. Node PW4					
a. Extraction Wells	EA	4	\$60,050	\$240,000	avg. well cost from TCB/TSM sheet
b. Connecting Piping	LF	4000	\$50	\$200,000	G.M. FS
c. Equalization Basin	GAL	15000	\$2	\$30,000	15 min retention time
d. Air Stripper	EA	1	\$205,487	\$205,000	PW4TCE.OUT
e. Surface Water Discharge Piping	LF	1000	\$50	\$50,000	G.M. FS

TOTAL DIRECT COSTS

\$2,208,000

INDIRECT CAPITAL COSTS (% of Direct Capital Costs)

1. Engineering & Design 15% of Direct Capital	\$331,000
2. Contingency Allowance 15% of Direct Capital	\$331,000
3. Other Indirect Costs	
A. Legal Fees 1%	\$22,000
B. Regulatory License/permits Costs 5%	\$110,000

TOTAL INDIRECT CAPITAL COSTS

\$794,000

TOTAL CAPITAL COSTS

\$3,002,000 (Rounded)

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 02/02/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

ITEM: ALTERNATIVE 2B - Limited Action, Limited Pumping with Natural Attenuation

ANNUAL/PERIODIC (O & M) COSTS							PRESENT	WORTH	Discount Rate	5.00%
COST COMPONENT	UNIT	FREQUENC	QUANTITY PER YEAR	UNIT COST	ANNUAL COST	LIFE OF ITEM (YEARS)	ANNUAL COST	PERIODIC COST	COST SOURCE	
DIRECT ANNUAL/PERIODIC COSTS:										
1.										
a. Source Control(Included under separate OU)	LS	Annual	0	\$0	\$0	125	\$0	n/a		
b. GW Monitoring	LS	Quarterly	140	\$300	\$42,000	125	\$838,000	n/a	TCB	
c. Remedy as necessary	LS	Annual	1	\$1,500	\$1,500	125	\$30,000	n/a	G.M. FS	
2. Institutional Controls										
a. Public Education Programs	LS	Monthly	12	\$700	\$8,400	125	\$168,000	n/a	G.M. FS	
b. City Water Mains	LS	Annual	0	\$0	\$0	125	\$0	n/a	Turn over mains to city	
c. City Water Service Connections	LS	Annual	0	\$0	\$0	125	\$0	n/a	Turn over mains to city	
3. Node PW4										
a. Extraction Wells	EA	Annual	4	\$34,846	\$138,400	125	\$2,783,000	n/a	avg. well cost from TCB/T	
b. Connecting Piping	LF	Annual	4000	\$10	\$40,000	125	\$798,000	n/a	replace @ 5yr :. \$10/ft/yr	
c. Equalization Basin	LS	Annual	1	\$0	\$0	125	\$0	n/a		
d. Air Stripper	LS	Annual	1	\$39,987	\$40,000	125	\$798,000	n/a	PW4TCE.OUT	
e. Discharge Piping	LF	Annual	1000	\$10	\$10,000	125	\$200,000	n/a	replace @ 5yr :. \$10/ft/yr	
TOTAL DIRECT ANNUAL/PERIODIC COSTS (Rounded):					\$281,000					
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$5,615,000	\$0		
INDIRECT ANNUAL/PERIODIC COSTS (% of Direct Annual/Periodic Costs):										
Administration (5%)	LS	Annual	1	\$14,050	\$14,100	125	\$281,000	n/a		
Insurance, Taxes and Licenses (5%)	LS	Annual	1	\$14,050	\$14,100	125	\$281,000	n/a		
Maintenance Reserve & Contingency Costs (15%)	LS	Annual	1	\$42,150	\$42,200	125	\$842,000	n/a		
TOTAL INDIRECT ANNUAL/PERIODIC COSTS:					\$70,000					
TOTAL INDIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$1,404,000	\$0		
TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):							\$5,615,000	\$0		
TOTAL ANNUAL/PERIODIC PRESENT WORTH COSTS:							\$7,019,000	\$0		
TOTAL DIRECT COST					\$2,208,000					
TOTAL INDIRECT CAPITAL COSTS					\$794,000					
TOTAL ANNUAL/PERIODIC COSTS (DIRECT +INDIRECT)					\$7,019,000					
TOTAL PRESENT WORTH (CAPITAL + ANNUAL/PERIODIC COSTS):					\$10,021,000					

**Estimated Extraction Costs for Groundwater
Alt. 2b**

IL-EPA
SE Rockford, IL

ITEM	DESCRIPTION	No.	Unit	Unit Price	Total
1	Work Plan/HSP	1	LS	\$ 8,500	\$ 8,500
2	Drilling				
	Mobilization	1	LS	\$ 5,000	\$ 5,000
	Drilling & Installing	800	LF	\$ 90	\$ 72,000
	Development	4	EA	\$ 1,500	\$ 6,000
	Waste Sampling and Testing	4	EA	\$ 700	\$ 2,800
	Misc. Testing/Geotech., Hydr.	1	LS	\$ 1,600	\$ 1,600
3	Well Completion				
	Sump	4	EA	\$ 12,500	\$ 50,000
	Controllers/Elect.	1	LS	\$9,200	\$ 9,200
	Pumps & Starters 70gpm	0	EA	\$ 6,000	-
	250gpm	4	EA	\$ 20,000	\$ 80,000
	333gpm	0	EA	\$ 50,000	-
4	Waste Disposal	35	CY	\$ 146	\$ 5,100
	Sub-Total				\$ 240,200
	Avg Well Cost				\$ 60,050
	Engineering (20%)				\$ 48,040
	Contingency (15%)				\$ 36,030
	Total				\$ 324,270

BY: TCB/TSM
COSTS2.XLS

**Estimated Extraction Costs for Groundwater
Alt. 2b**

IL-EPA
SE Rockford, IL

ITEM	DESCRIPTION	No.	Unit	Unit Price	Total
1	O&M Plan	1	LS	\$ 12,000	\$ 12,000
2	Monitoring				
	Groundwater Wells	1	LS	\$ 42,960	\$ 42,960
	Effluent	1	EA	\$ 2,640	\$ 2,640
	Reporting	1	LS	\$ 12,000	\$ 12,000
3	Replacement Costs (once per five years, reported annually)				
	Groundwater Extraction	1	LS	\$ 170,900	\$ 29,456
4	Power Requirements (per Annum)				
	Pumping	504,140	KW*HR	\$ 0.08	\$ 40,331
	Annual Sub-Total				\$ 139,387
	Avg Well Cost				\$ 34,847
	Present Worth for 125 years of Operation @ 5%				\$ 2,554,018

O&M Plan as LS @ Yr 0

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1881-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

SCREENING OF ALTERNATIVES COST ESTIMATING WORKSHEET (+50% TO -30% Level)

Current ENR Construction Cost Index: 5300

ITEM: ALTERNATIVE 3A - Full Action with Offsite Disposal to Surface Water

DESCRIPTION: Source control, monitoring of new and existing wells, institutional controls, extraction wells at node PW1 - PW3B and PW5-PW8, connecting piping, equalization basins, air strippers and GAC @ PW3A. Treated water discharged to city storm sewer system.

DIRECT CAPITAL COSTS

(Includes Labor, Equipment & Materials, Unless Otherwise Noted)

	COST COMPONENT	UNIT	QUANTITY	UNIT COST	TOTAL CAPITAL COST	COST SOURCE
1.						
	a. Source Control(included under separate OU)	EA	0	\$0	\$0	
	b. Monitoring Locations(2 wells/location)	EA	5	\$5,000	\$25,000	G.M. FS
2.	Institutional Controls					
	a. City Water Mains	LF	21000	\$50	\$1,058,000	1990 CDM 6" Steel Pipe (update fromCCI @ 4732)
	b. City Water Service Connections	EA	400	\$1,000	\$400,000	
3.	Node PW4					
	a. Extraction Wells	EA	0	\$66,386	\$0	
	b. Connecting Piping	LF	0	\$50	\$0	
	c. Equalization Basin	GAL	0	\$2	\$0	PW4 NOT USED
	d. Air Stripper	EA	0	\$205,487	\$0	PW4TCE.OUT
	e. Surface Water Discharge Piping	LF	0	\$50	\$0	
4.1	Node PW1					
	a. Extraction Wells	EA	4	\$66,386	\$266,000	avg. well cost from TCB/TSM sheet
	b. Connecting Piping	LF	2900	\$50	\$145,000	G.M. FS
	c. Equalization Basin	GAL	20000	\$2	\$40,000	15 min retention time
	d. Air Stripper	EA	1	\$270,420	\$270,000	PW1TCE.OUT
	e. Surface Water Discharge Piping	LF	3400	\$50	\$170,000	PS cost from EPA Inno. & Alt. Tech. Guide, 1MGD
4.2	Node PW2					
	a. Extraction Wells	EA	5	\$66,386	\$332,000	
	b. Connecting Piping	LF	4300	\$50	\$215,000	
	c. Equalization Basin	GAL	25000	\$2	\$50,000	
	d. Air Stripper	EA	1	\$429,553	\$430,000	PW2TCA2.OUT
	e. Surface Water Discharge Piping	LF	3000	\$50	\$150,000	
4.3	Node PW3A					
	a. Extraction Wells	EA	2	\$66,386	\$133,000	
	b. Connecting Piping	LF	3100	\$50	\$155,000	
	c. Equalization Basin	GAL	7500	\$2	\$15,000	
	d. Air Stripper	EA	1	\$290,807	\$291,000	PW3ABEN.OUT
	e. GAC Off Gas	LS	1	\$133,186	\$133,000	PW3ATOL.OUT
	f. Surface Water Discharge Piping	LF	2000	\$50	\$100,000	

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

4.4 Node PW3B

a. Extraction Wells	EA	2	\$66,386	\$133,000	
b. Connecting Piping	LF	1300	\$50	\$65,000	
c. Equalization Basin	GAL	7500	\$2	\$15,000	
d. Air Stripper	EA	1	\$122,640	\$123,000	PW3BTCE.OUT
e. Surface Water Discharge Piping	LF	w/above	\$50	\$0	

4.5 Node PWS

a. Extraction Wells	EA	4	\$66,386	\$266,000	
b. Connecting Piping	LF	1600	\$50	\$80,000	
c. Equalization Basin	GAL	15000	\$2	\$30,000	
d. Air Stripper	EA	1	\$349,653	\$350,000	PW5TCA2.OUT
e. Surface Water Discharge Piping	LF	100	\$50	\$5,000	

4.6 Node PW6

a. Extraction Wells	EA	5	\$66,386	\$332,000	
b. Connecting Piping	LF	2100	\$50	\$105,000	
c. Equalization Basin	GAL	5250	\$2	\$11,000	
d. Air Stripper	EA	1	\$187,347	\$187,000	PW6TCA2.OUT
e. Surface Water Discharge Piping	LF	100	\$50	\$5,000	

TOTAL DIRECT COSTS \$6,065,000

INDIRECT CAPITAL COSTS (% of Direct Capital Costs)

1. Engineering & Design 15% of Direct Capital	\$913,000
2. Contingency Allowance 15% of Direct Capital	\$913,000
3. Other Indirect Costs	
A. Legal Fees 1%	\$61,000
B. Regulatory License/permits Costs 5%	\$304,000

TOTAL INDIRECT CAPITAL COSTS \$2,191,000

TOTAL CAPITAL COSTS \$8,276,000 (Rounded)

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

ITEM: ALTERNATIVE 3A - Full Action with Offsite Disposal to Surface Water

						PRESENT	WORTH	Discount Rate	5.00%
ANNUAL/PERIODIC (O & M) COSTS									
COST COMPONENT	UNIT	FREQUENC	QUANTITY PER YEAR	UNIT COST	ANNUAL COST	LIFE OF ITEM (YEARS)	ANNUAL COST	PERIODI COST	COST SOURCE
DIRECT ANNUAL/PERIODIC COSTS:									
1.									
a. Source Control(Included under separate OU)	LS	Annual	0	\$0	\$0	75	\$0	n/a	
b. GW Monitoring	LS	Quarterly	140	\$300	\$42,000	75	\$820,000	n/a	TCB
c. Remedy as necessary	LS	Annual	1	\$1,500	\$1,500	75	\$29,000	n/a	G.M. FS
2. Institutional Controls									
a. Public Education Programs	LS	Monthly	12	\$700	\$8,400	75	\$164,000	n/a	G.M. FS
b. City Water Mains	LS	Annual	0	\$0	\$0	75	\$0	n/a	Turn over mains to city
c. City Water Service Connections	LS	Annual	0	\$0	\$0	75	\$0	n/a	Turn over mains to city
3. Node PW4									
a. Extraction Wells	EA	Annual	0	\$23,597	\$0	75	\$0	n/a	
b. Connecting Piping	LF	Annual	0	\$10	\$0	75	\$0	n/a	
c. Equalization Basin	LS	Annual	0	\$0	\$0	75	\$0	n/a	PW4 NOT USED
d. Air Stripper	LS	Annual	0	\$39,987	\$0	75	\$0	n/a	PW4TCE.OUT
e. Discharge Piping	LF	Annual	0	\$10	\$0	75	\$0	n/a	
4.1 Node PW1									
a. Extraction Wells	EA	Annual	4	\$23,597	\$94,400	75	\$1,843,000	n/a	avg. well cost from TCB/TSM sheet
b. Connecting Piping	LF	Annual	2900	\$10	\$29,000	75	\$566,000	n/a	replace @ 5yr :: use \$10/ft/yr
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a	
d. Air Stripper	LS	Annual	1	\$52,982	\$53,000	75	\$1,035,000	n/a	PW1TCE.OUT
e. Discharge Piping	LF	Annual	3400	\$10	\$34,000	75	\$664,000	n/a	replace @ 5yr :: use \$10/ft/yr
4.2 Node PW2									
a. Extraction Wells	EA	Annual	5	\$23,597	\$118,000	75	\$2,304,000	n/a	
b. Connecting Piping	LF	Annual	4300	\$10	\$43,000	75	\$840,000	n/a	
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a	
d. Air Stripper	LS	Annual	1	\$73,548	\$73,500	75	\$1,435,000	n/a	PW2TCA2.OUT
e. Discharge Piping	LF	Annual	3000	\$10	\$30,000	75	\$586,000	n/a	
4.3 Node PW3A									
a. Extraction Wells	EA	Annual	2	\$23,597	\$47,200	75	\$922,000	n/a	
b. Connecting Piping	LF	Annual	3100	\$10	\$31,000	75	\$605,000	n/a	
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a	
d. Air Stripper	LS	Annual	1	\$32,642	\$32,600	75	\$637,000	n/a	PW3ABEN.OUT
e. GAC Off Gas	LS	Annual	1	\$681,528	\$675,754	75	\$13,195,000	n/a	PW3ATOL.OUT
f. Discharge Piping	LF	Annual	2000	\$10	\$20,000	75	\$391,000	n/a	

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

4.4 Node PW3B

a. Extraction Wells	EA	Annual	2	\$23,597	\$47,200	75	\$922,000	n/a
b. Connecting Piping	LF	Annual	1300	\$10	\$13,000	75	\$254,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$22,091	\$22,100	75	\$432,000	n/a PW3BTCE.OUT
e. Discharge Piping	LF	Annual	w/above	\$10	\$0	75	\$0	n/a

4.5 Node PW5

a. Extraction Wells	EA	Annual	4	\$23,597	\$94,400	75	\$1,843,000	n/a
b. Connecting Piping	LF	Annual	1800	\$10	\$18,000	75	\$312,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$49,956	\$50,000	75	\$976,000	n/a PW5TCA2.OUT
e. Discharge Piping	LF	Annual	100	\$10	\$1,000	75	\$20,000	n/a

4.6 Node PW6

a. Extraction Wells	EA	Annual	5	\$23,597	\$118,000	75	\$2,304,000	n/a
b. Connecting Piping	LF	Annual	2100	\$10	\$21,000	75	\$410,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$21,771	\$21,800	75	\$426,000	n/a PW6TCA2.OUT
e. Discharge Piping	LF	Annual	100	\$10	\$1,000	75	\$20,000	n/a

TOTAL DIRECT ANNUAL/PERIODIC COSTS (Rounded):

\$1,739,000

TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):

\$33,955,000 \$0

INDIRECT ANNUAL/PERIODIC COSTS (% of Direct Annual/Periodic Costs):

Administration (5%)	LS	Annual	1	\$86,950	\$87,000	75	\$1,699,000	n/a
Insurance, Taxes and Licenses (5%)	LS	Annual	1	\$86,950	\$87,000	75	\$1,699,000	n/a
Maintenance Reserve & Contingency Costs (15%)	LS	Annual	1	\$260,850	\$260,900	75	\$5,084,000	n/a

TOTAL INDIRECT ANNUAL/PERIODIC COSTS:

\$435,000

TOTAL INDIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS:

\$8,492,000 \$0

TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded):

\$33,955,000 \$0

TOTAL ANNUAL/PERIODIC PRESENT WORTH COSTS:

\$42,447,000 \$0

TOTAL DIRECT COST

\$6,085,000

TOTAL INDIRECT CAPITAL COSTS

\$2,191,000

TOTAL ANNUAL/PERIODIC COSTS (DIRECT +INDIRECT)

\$42,447,000

TOTAL PRESENT WORTH (CAPITAL + ANNUAL/PERIODIC COSTS):

\$50,723,000

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
 JOB #: 1681-007-FS-FSANL

CHK BY: SER
 DATE: 05/04/95

SCREENING OF ALTERNATIVES COST ESTIMATING WORKSHEET (+50% TO -30% Level)

Current ENR Construction Cost Index: 5300

ITEM: ALTERNATIVE 3B - Full Action with Offsite Discharge to Potable

DESCRIPTION: Source control, monitoring of new and existing wells, institutional controls, extraction wells at node PW1 - PW3B and PW5-PW8, connecting piping, equalization basins, air strippers and GAC @ PW3A. Treated water discharge sold to city potable water system.

DIRECT CAPITAL COSTS

(Includes Labor, Equipment & Materials, Unless Otherwise Noted)

	COST COMPONENT	UNIT	QUANTITY	UNIT COST	TOTAL CAPITAL COST	COST SOURCE
1.						
a.	Source Control(Included under separate OU)	EA	0	\$0	\$0	
b.	Monitoring Locations(2 wells/location)	EA	5	\$5,000	\$25,000	G.M. FS
2.	Institutional Controls					
a.	City Water Mains	LF	21000	\$50	\$1,058,000	1990 CDM 6" Steel Pipe (update fromCCI @ 4732)
b.	City Water Service Connections	LF	400	\$1,000	\$400,000	
3.	Node PW4					
a.	Extraction Wells	EA	0	\$66,386	\$0	
b.	Connecting Piping	LF	0	\$50	\$0	
c.	Equalization Basin	GAL	0	\$2	\$0	PW4 NOT USED
d.	Air Stripper	EA	0	\$205,487	\$0	PW4TCE.OUT
e.	150 psi Booster Pump	LS	0	\$974,343	\$0	
4.1	Node PW1					
a.	Extraction Wells	EA	4	\$66,386	\$266,000	avg. well cost from TCB/TSM sheet
b.	Connecting Piping	LF	2800	\$50	\$145,000	G.M. FS
c.	Equalization Basin	GAL	20000	\$2	\$40,000	15 min retention time
d.	Air Stripper	EA	1	\$270,420	\$270,000	PW1TCE.OUT
e.	150 psi Booster Pump	LS	1	\$974,343	\$974,000	PS cost from EPA Inno. & Alt. Tech. Guide, 1MGD
4.2	Node PW2					
a.	Extraction Wells	EA	5	\$66,386	\$332,000	
b.	Connecting Piping	LF	4300	\$50	\$215,000	
c.	Equalization Basin	GAL	25000	\$2	\$50,000	
d.	Air Stripper	EA	1	\$429,553	\$430,000	PW2TCA2.OUT
e.	150 psi Booster Pump	LS	1	\$974,343	\$974,000	
4.3	Node PW3A					
a.	Extraction Wells	EA	2	\$66,386	\$133,000	
b.	Connecting Piping	LF	3100	\$50	\$155,000	
c.	Equalization Basin	GAL	7500	\$2	\$15,000	
d.	Air Stripper	EA	1	\$290,807	\$291,000	PW3ABEN.OUT
e.	GAC Off Gas	LS	1	\$133,186	\$133,000	PW3ATOL.OUT
f.	150 psi Booster Pump	LS	1	\$974,343	\$974,000	

Camp Dresser & McKee Inc.
 BY: T. Mercer
 DATE: 05/04/95
 CLIENT: IL-EPA
 PROJECT: SE Rockford, IL
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4.4 Node PW3B

a. Extraction Wells	EA	2	\$66,386	\$133,000	
b. Connecting Piping	LF	1300	\$50	\$65,000	
c. Equalization Basin	GAL	7500	\$2	\$15,000	
d. Air Stripper	EA	1	\$122,640	\$123,000	PW3BTCE.OUT
e. 150 psi Booster Pump	LS	w/above	\$0	\$0	

4.5 Node PW5

a. Extraction Wells	EA	4	\$66,386	\$266,000	
b. Connecting Piping	LF	1600	\$50	\$80,000	
c. Equalization Basin	GAL	15000	\$2	\$30,000	
d. Air Stripper	EA	1	\$349,653	\$350,000	PW5TCA2.OUT
e. 150 psi Booster Pump	LS	1	\$974,343	\$974,000	

4.6 Node PW6

a. Extraction Wells	EA	5	\$66,386	\$332,000	
b. Connecting Piping	LF	2100	\$50	\$105,000	
c. Equalization Basin	GAL	5250	\$2	\$11,000	
d. Air Stripper	EA	1	\$187,347	\$187,000	PW6TCA2.OUT
e. 150 psi Booster Pump	LS	1	\$974,343	\$974,000	

TOTAL DIRECT COSTS	<u>\$10,525,000</u>
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INDIRECT CAPITAL COSTS (% of Direct Capital Costs)

1. Engineering & Design 15% of Direct Capital	\$1,579,000
2. Contingency Allowance 15% of Direct Capital	\$1,579,000
3. Other Indirect Costs	
A. Legal Fees 1%	\$105,000
B. Regulatory License/permits Costs 5%	\$528,000

TOTAL INDIRECT CAPITAL COSTS	<u>\$3,789,000</u>
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TOTAL CAPITAL COSTS	<u>\$14,314,000 (Rounded)</u>
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ITEM: ALTERNATIVE 3B - Full Action with Offsite Discharge to Potable

							PRESENT	WORTH	Discount Rate	5.00%
ANNUAL/PERIODIC (O & M) COSTS										
COST COMPONENT	UNIT	FREQUENC	QUANTITY PER YEAR	UNIT COST	ANNUAL COST	LIFE OF ITEM (YEARS)	ANNUAL COST	PERIODIC COST	COST SOURCE	
DIRECT ANNUAL/PERIODIC COSTS:										
1.										
a. Source Control(Included under separate OU)	LS	Annual	0	\$0	\$0	75	\$0	n/a		
b. GW Monitoring	LS	Quarterly	140	\$300	\$42,000	75	\$820,000	n/a	TCB	
c. Remedy as necessary	LS	Annual	1	\$1,500	\$1,500	75	\$29,000	n/a	G.M. FS	
2. Institutional Controls										
a. Public Education Programs	LS	Monthly	12	\$700	\$8,400	75	\$184,000	n/a	G.M. FS	
b. City Water Mains	LS	Annual	0	\$0	\$0	75	\$0	n/a	Turn over mains to city	
c. City Water Service Connections	LS	Annual	0	\$0	\$0	75	\$0	n/a	Turn over mains to city	
3. Node PW4										
a. Extraction Wells	EA	Annual	0	\$23,597	\$0	75	\$0	n/a		
b. Connecting Piping	LF	Annual	0	\$10	\$0	75	\$0	n/a		
c. Equalization Basin	LS	Annual	0	\$0	\$0	75	\$0	n/a	PW4 NOT USED	
d. Air Stripper	LS	Annual	0	\$39,967	\$0	75	\$0	n/a	PW4TCE.OUT	
e. 150 psi Booster Pump	LS	Annual	0	(\$262,800)	\$0	75	\$0	n/a		
4.1 Node PW1										
a. Extraction Wells	EA	Annual	4	\$23,597	\$94,400	75	\$1,843,000	n/a	avg. well cost from TCB/TSM sheet	
b. Connecting Piping	LF	Annual	2900	\$10	\$29,000	75	\$568,000	n/a	replace @ 5yr :: use \$10/ft/yr	
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a		
d. Air Stripper	LS	Annual	1	\$52,962	\$53,000	75	\$1,035,000	n/a	PW1TCE.OUT	
e. 150 psi Booster Pump	LS	Annual	1	(\$350,050)	(\$350,000)	75	(\$6,834,000)	n/a	\$0.5/1000 gal -revenue generation	
4.2 Node PW2										
a. Extraction Wells	EA	Annual	5	\$23,597	\$118,000	75	\$2,304,000	n/a		
b. Connecting Piping	LF	Annual	4300	\$10	\$43,000	75	\$840,000	n/a		
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a		
d. Air Stripper	LS	Annual	1	\$73,546	\$73,500	75	\$1,435,000	n/a	PW2TCA2.OUT	
e. 150 psi Booster Pump	LS	Annual	1	(\$437,562)	(\$437,600)	75	(\$8,545,000)	n/a		
4.3 Node PW3A										
a. Extraction Wells	EA	Annual	2	\$23,597	\$47,200	75	\$922,000	n/a		
b. Connecting Piping	LF	Annual	3100	\$10	\$31,000	75	\$605,000	n/a		
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a		
d. Air Stripper	LS	Annual	1	\$32,642	\$32,600	75	\$637,000	n/a	PW3ABEN.OUT	
e. GAC Off Gas	LS	Annual	1	\$675,754	\$675,800	75	\$13,198,000	n/a	PW3ATOL.OUT	
f. 150 psi Booster Pump	LS	Annual	1	(\$262,800)	(\$262,800)	75	(\$5,131,000)	n/a		

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4.4 Node PW3B

a. Extraction Wells	EA	Annual	2	\$23,597	\$47,200	75	\$922,000	n/a
b. Connecting Piping	LF	Annual	1300	\$10	\$13,000	75	\$254,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$22,091	\$22,100	75	\$432,000	n/a PW3BTCE.OUT
e. 150 psi Booster Pump	LS	Annual	w/above	(\$262,800)	\$0	75	\$0	n/a

4.5 Node PW5

a. Extraction Wells	EA	Annual	4	\$23,597	\$94,400	75	\$1,843,000	n/a
b. Connecting Piping	LF	Annual	1600	\$10	\$16,000	75	\$312,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$49,958	\$50,000	75	\$976,000	n/a PW5TCA2.OUT
e. 150 psi Booster Pump	LS	Annual	1	(\$262,800)	(\$262,800)	75	(\$5,131,000)	n/a

4.6 Node PW6

a. Extraction Wells	EA	Annual	5	\$23,597	\$118,000	75	\$2,304,000	n/a
b. Connecting Piping	LF	Annual	2100	\$10	\$21,000	75	\$410,000	n/a
c. Equalization Basin	LS	Annual	1	\$0	\$0	75	\$0	n/a
d. Air Stripper	LS	Annual	1	\$21,771	\$21,800	75	\$426,000	n/a PW6TCA2.OUT
e. 150 psi Booster Pump	LS	Annual	1	(\$91,960)	(\$92,000)	75	(\$1,796,000)	n/a

TOTAL DIRECT ANNUAL/PERIODIC COSTS (Rounded): \$248,000

TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded): \$4,838,000 \$0

INDIRECT ANNUAL/PERIODIC COSTS (% of Direct Annual/Periodic Costs):

Administration (5%)	LS	Annual	1	\$12,400	\$12,400	75	\$242,000	n/a
Insurance, Taxes and Licenses (5%)	LS	Annual	1	\$12,400	\$12,400	75	\$242,000	n/a
Maintenance Reserve & Contingency Costs (15%)	LS	Annual	1	\$37,200	\$37,200	75	\$726,000	n/a

TOTAL INDIRECT ANNUAL/PERIODIC COSTS: \$62,000

TOTAL INDIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS: \$1,210,000 \$0

TOTAL DIRECT ANNUAL/PERIODIC PRESENT WORTH COSTS (Rounded): \$4,838,000 \$0

TOTAL ANNUAL/PERIODIC PRESENT WORTH COSTS: \$6,048,000 \$0

TOTAL DIRECT COST \$10,525,000

TOTAL INDIRECT CAPITAL COSTS \$3,789,000

TOTAL ANNUAL/PERIODIC COSTS (DIRECT +INDIRECT) \$6,048,000

TOTAL PRESENT WORTH (CAPITAL + ANNUAL/PERIODIC COSTS): \$20,362,000

**Estimated Extraction Costs for Groundwater
Alt. 3a 3b**

IL-EPA
SE Rockford, IL

ITEM	DESCRIPTION	No.	Unit	Unit Price	Total
1	Work Plan/HSP	1	LS	\$ 8,500	\$ 8,500
2	Drilling				
	Mobilization	1	LS	\$ 5,000	\$ 5,000
	Drilling & Installing	4400	LF	\$ 90	\$ 396,000
	Development	22	EA	\$ 1,500	\$ 33,000
	Waste Sampling and Testing	22	EA	\$ 700	\$ 15,400
	Misc. Testing/Geotech., Hydr.	1	LS	\$ 8,800	\$ 8,800
3	Well Completion				
	Sump	22	EA	\$ 12,500	\$ 275,000
	Controllers/Elect.	1	LS	\$ 50,769	\$ 50,769
	Pumps & Starters 70gpm	5	EA	\$ 6,000	\$ 30,000
	250gpm	8	EA	\$ 20,000	\$ 160,000
	333gpm	9	EA	\$ 50,000	\$ 450,000
4	Waste Disposal	192	CY	\$ 146	\$ 28,016
	Sub-Total				\$ 1,460,485
	Avg Well Cost				\$ 66,386
	Engineering (20%)				\$ 292,097
	Contingency (15%)				\$ 219,073
	Total				\$ 1,971,655

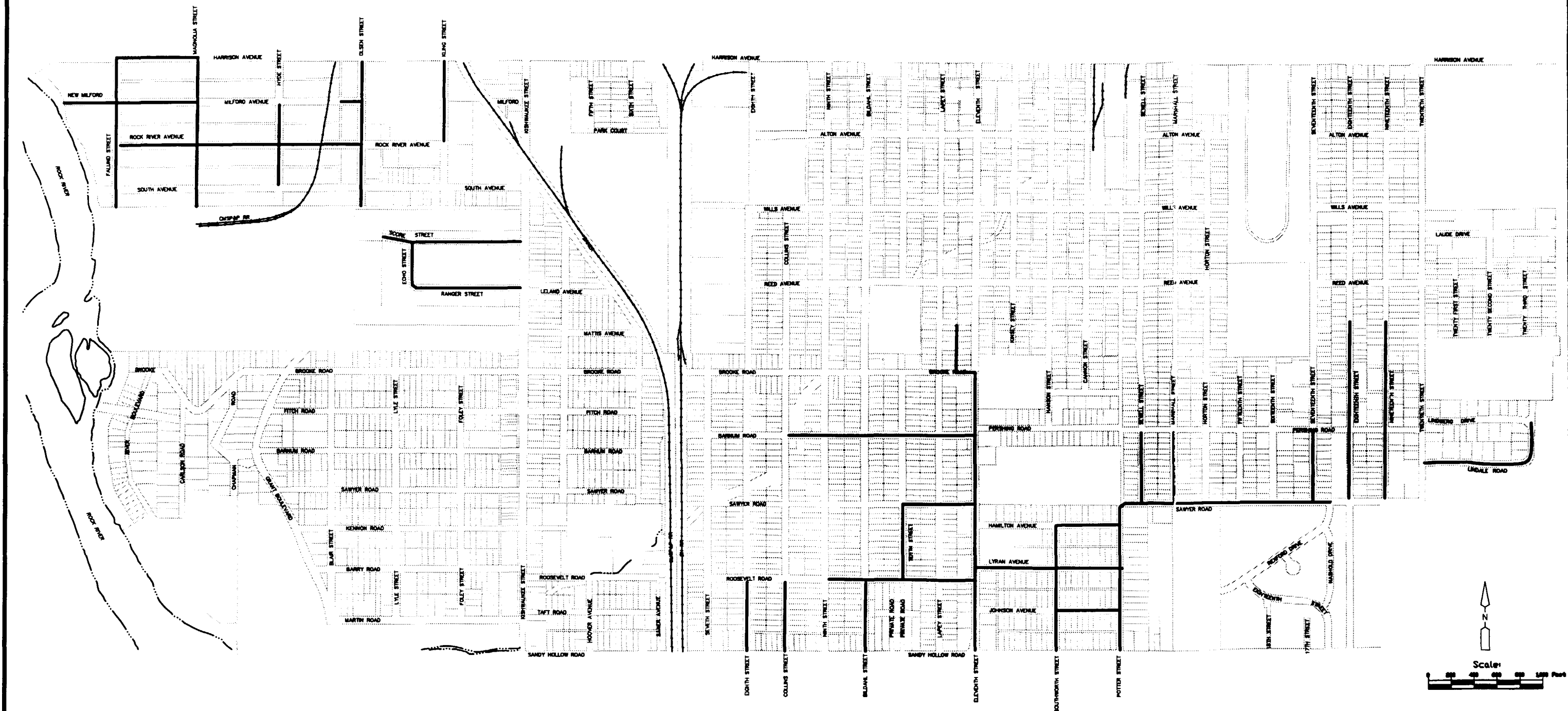
BY: TCB/TSM
COSTS.XLS

**Estimated Extraction Costs for Groundwater
Alt. 3a 3b**

IL-EPA
SE Rockford, IL

ITEM	DESCRIPTION	No.	Unit	Unit Price	Total
1	O&M Plan	1	LS	\$ 16,000	\$ 16,000
2	Monitoring				
	Groundwater Wells	1	LS	\$ 160,080	\$ 160,080
	Effluent	5	EA	\$ 2,640	\$ 13,200
	Reporting	1	LS	\$ 16,000	\$ 16,000
3	Replacement Costs (once per five years, reported annually)				
	Groundwater Extraction	1	LS	\$ 1,117,416	\$ 192,594
4	Power Requirements (per Annum)				
	Pumping	2,695,634	KW*HR	\$ 0.08	\$ 215,651
	Annual Sub-Total				\$ 613,525
	Avg Well Cost				\$ 23,597
	Present Worth for 75 years of Operation @ 5%				\$ 11,658,759

O&M Plan as LS @ Yr 0



SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY

CITY POTABLE WATER SYSTEM EXPANSION

CDM

environmental engineers, scientists,
planners, & management consultants

Figure No. B-1

Appendix C



Appendix C
Groundwater and Contaminant
Transport Simulations

Appendix C

Groundwater and Contaminant Transport Simulations

C.1 Introduction

This Appendix summarizes the results of groundwater flow and contaminant transport simulations conducted for the Southeast Rockford Feasibility Study. The simulations were done to assess the future impact of contamination on discharge points such as the Rock River and water supply wells, and to assist evaluation of groundwater remediation alternatives at the site. The starting point for the feasibility study (FS) modeling is the calibrated flow and transport model described in the Remedial Investigation (RI) Report (CDM 1994). The RI model represents conditions existing as of October 1993. For the purpose of discussion, it is assumed that the calibrated model represents site conditions at the end of 1993. Hence, the FS simulations described in this report begin on the first day of 1994. Details of the calibrated model are given in section 5 of the RI Report. The general approach adopted for the FS modeling and the limitations of the future simulations are described next, followed by results for the three remedial alternatives addressed in this FS.

C.2 Modeling Approach

The calibrated flow and transport model developed for the RI was used as the starting point for the FS modeling. Two changes to the finite-element grid were made for the FS modeling. First, the model layer representing the unconsolidated glacial sediments in the RI model was subdivided into two layers, Layers 5 and 6, to provide better vertical resolution for remedial pumping, as shown in cross-section in Figure 1. The location of the cross-section is shown in Figure 2. Level 6 represents the upper part of the unconsolidated aquifer in all portions of the study area, and Level 5 is the contact between the unconsolidated aquifer and the underlying dolomite aquifer except in the ancestral Rock Bedrock Valley where the Galena and Platteville Groups (dolomite) are eroded. Similarly, the Glenwood Formation (Layer 3) is eroded in the Rock Bedrock Valley. Valley Deposits (see Figure 1) now occupy the ancient bedrock valley. The calibration of the model is not affected by the additional layer because the flow and transport properties of the combined layers are identical to the original layer.

The second change to the grid consisted of adding nodes to represent remediation pumping. A total of 22 new and existing nodes were designated as remediation pumping nodes at Levels 5 and 6, where the majority of groundwater contamination occurs. In the model, a remediation pumping node removes groundwater from the vertical interval spanning the lower half of the layer located above the node to the upper half of the layer below the node. For example, a Level 5 pumping node pumps from the lower half of the unconsolidated unit (Layer 5) and the upper half of the dolomite unit (Layer 4). Similarly, a Level 6 pumping node influences the lower half of Layer 6 and the upper half of Layer 5. Pumping rates were adjusted to avoid dewatering the pumping interval. Detailed capture zone analysis will be performed during remedial design once additional site-specific data are available (e.g., pump tests). Location of the individual pumping nodes is shown by the letter "P" in Figure 2.

Pumping node locations were chosen with the objective to remediate the simulated groundwater plume to achieve ARAR compliance for TCA. Pumping nodes at locations PW1 through PW3

were assigned to Level 6, and nodes at PW4 through PW6 were assigned to Level 5 to remediate TCA-DCA concentrations exceeding 200 ug/L, the ARAR for TCA. TCA concentrations greater than 200 ug/L in the simulated plume occur in the unconsolidated layer and the upper part of the dolomite layer, as shown in Figures 3 through 6.

Pumping fluxes for five recently-installed city water supply wells were added to the FS model. These fluxes are listed in Table 1.

Table 1
Pumping Fluxes for Recently-Installed Unit Wells
(in millions of gal.)

Unit Well	Pumping Flux (1993)
UW34	245.457
UW37	535.032
UW39	111.876
UW40	562.368
UW42	296.541

Information for these wells was received after the RI had been submitted. Only one of the four new wells, UW34 (Figure 2), is located close enough to the study area to influence the simulations; UW34 is open to the St. Peter Sandstone (Layer 2) and underlying formations. Active unit wells within the study area include UW6, UW10, UW16, and UW35. Of these wells, UW35 is the most relevant to the FS modeling because it is screened in the unconsolidated aquifer and has a history of VOC contamination. The calibration of the model was not affected by the addition of the new unit well fluxes.

Source areas 4, 7, 8, 9/10, and 14 (see Figure 2 for locations) from the calibrated transport model were included in the evaluation of the remedial alternatives addressed in this FS. Each source becomes inactive at different times during the transport simulations. Available information indicates that Source Area 14 was remediated by 1988, and Source Area 8 was remediated beginning in 1986. In the contaminant transport simulations described below, it is assumed that Source Area 8 was shut off at the end of 1993 (i.e., Source Area 8 was treated as an inactive source in the FS simulations). The following cleanup times for the three remaining source areas were incorporated in the FS contaminant transport simulations:

Table 2
Source Area Cleanup Times Used in Simulations

Source Area	Estimated Cleanup Time (yr)
4	10
7	20
9/10	15

Exponential decay rates and source strengths from the calibrated transport model were used for the source areas while they remained active.

The contaminants in the calibrated transport model are 1,1,1-trichloroethane (TCA) and its degradation product 1,1-dichloroethane (DCA). TCA was chosen for the transport model because it is present most consistently and at higher concentrations than other contaminants at the site, and is generally a good indicator of the presence of other VOCs. Details of the transport model are given in CDM (1994). Although both TCA and DCA were used in the calibrated transport model, for the purposes of this FS, the simulated TCA-DCA concentrations are compared to ARARs for TCA.

C.3 Limitations of Future Simulations

The future contaminant transport results presented below represent predictions of what might happen if the assumptions on which the simulation are based are realized. Factors such as extreme meteorological conditions (drought and flood) and unanticipated pumping cannot be predicted with any precision and therefore were not incorporated in the future simulations. These factors can affect groundwater flow and thereby mass transport. The accuracy of the predictive simulations is also subject to the timing of source area removal and the inherent uncertainties of the calibrated flow and transport model (CDM 1994). Absolute values for groundwater cleanup times and future concentrations should be considered estimates only; however, because the same assumptions regarding recharge, surface water elevations, unit well pumping etc. are used in each simulation, direct comparison among the various remedial alternatives is generally valid. It should be emphasized that the time estimates for groundwater cleanup apply to TCA only.

For each of the three alternatives addressed in this FS, future simulations were conducted for two cases: 1) the sources (Areas 4, 7, and 9/10) are not remediated and 2) the sources are remediated using the estimated source cleanup times in Table 2. The case in which the sources are not remediated was examined to provide an upper bound for the time needed to remediate groundwater. In each simulation, TCA concentrations were examined at 10-year intervals to determine the time required for the maximum concentration in groundwater to fall below 200 ug/L. An uncertainty of plus or minus 25 years was then assigned to this time; the upper end of this time interval was used for costing the remedial alternatives (205 years for No Action; 125 years for Limited Action 2b; 75 years for MCL Alternative), as described in section 5 of the FS. Results of these simulations are presented below.

C.4 No Action Alternative

Simulations for the No Action alternative show that TCA concentrations in groundwater fall below 200 ug/L within 280 years if the source areas are not remediated, and 190 years if the sources are removed according to the timeframe given in Table 2. Contamination will be removed during pumping at unit wells UW34 and UW35. The mean and maximum surface water concentrations of TCA-DCA in the Rock River are expected to be less than typical analytical detection limits. Simulations of future contaminant distribution under the No Action alternative were conducted for two scenarios: (1) Source areas are not remediated, and (2) Source areas are remediated according to the cleanup times previously discussed. Present-day (i.e., 1993) pumping rates at the City of Rockford's water supply wells were used in the simulations for the No Action Alternative; however, no remediation pumping was incorporated for this alternative.

C.4.1 Sources Not Remediated (No Action)

Figures 7 and 8 show the simulated TCA-DCA concentrations after 270 and 280 years, respectively, assuming that the modeled source areas are not remediated. A small area of TCA-DCA greater than 200 ug/L occurs west of 11th Street (Figure 7). Within 280 years, concentrations remain below 200 ug/L. TCA-DCA concentrations are less than 200 ug/L in other layers.

C.4.2 Sources Remediated (No Action)

Figures 9 and 10 show the simulated TCA-DCA concentrations after 180 and 190 years, respectively, assuming that the modeled source areas are remediated according to the cleanup times listed in Table 2. After 180 years, a small area of contamination greater than 200 ug/L is present in the Valley Fill southeast of the intersection of 11th Street and Harrison Avenue. Figure 10 shows that within 190 years, groundwater concentrations are below 200 ug/L.

C.4.3 Contaminant Loading to the Rock River

Contaminant transport simulations 30 and 50 years into the future indicate that TCA-DCA will discharge to the Rock River and water supply wells UW35 and UW34 (Table 3). The 30-year simulation shows that similar amounts of TCA-DCA will discharge to the river even if the source areas are remediated according to the time frame given in Table 2. This result likely reflects the fact that the source areas are inactive for only 10 to 20 years in the 30-year simulation, whereas in the 50-year simulations they are inactive for 30 to 40 years (Table 3). It is reasonable to expect that for a given simulation period, less contamination will reach the river as more time elapses after remediation of the source areas, relative to the situation where the sources remain active for all or most of the simulation. The 50-year simulation shows that the amount of TCA-DCA reaching the river is less (relative to the no source remediation scenario) for the case in which the sources are remediated. That is, the simulated effect of source area remediation on the river is apparent by the 50th year.

The future contaminant transport simulations indicate that TCA-DCA will be removed at the city's unit well UW35 if it is pumped at its 1993 rate of 224 million gallons per year. The removal of contamination at UW35 is consistent with its past history and with its location within a known groundwater contamination plume. Accordingly, a granular activated carbon treatment system was installed at UW35 in 1992. The total amount of TCA-DCA removed at UW34 in the simulations constitutes only a small fraction, typically less than 0.2 percent, of the total discharged mass. Similarly, the amount of TCA-DCA removed at invoked RISI nodes is relatively small, comprising less than 1.5 percent of the total removed mass. Invoked RISI nodes represent areas in the model, typically topographic lows in areas of groundwater discharge, where the elevation of the simulated water table exceeds the ground surface. Because the invoked RISI nodes at which mass is removed are located adjacent to the Rock River, these nodes are included with the river mass in the surface water calculations presented below.

The future surface water concentrations of TCA-DCA in the Rock River were estimated to be the same whether or not the sources are remediated. This was obtained by comparing the simulated contaminant mass discharged to the river and the estimated volume of river water that the mass is likely to mix with during the 30-year period. The mass transport simulations indicate that an annual mean of approximately 1.05×10^{11} ug of TCA-DCA is discharged to the river during 30 years (Table 3). In a given year, an estimated 3.56×10^{12} liters of surface water will mix with the mass, based on an annual mean discharge of 3,990 ft³/s for the Rock River (Maurer et al., 1993). Thus, the mean annual concentration of TCA-DCA in river water over the 30-year period is 0.03 ug/l, which is roughly four orders of magnitude smaller than the 200 ug/l MCL for TCA, and about two orders of magnitude less than the typical analytical detection limit of 1 ug/l; the relevant ambient water quality criterion for protection of human health against toxic effects is 18.4×10^3 ug/l. The discharge value is the annual mean for over 50 years of data from a gaging station located approximately 15 miles north (i.e., upstream) of the study area in Rockton, Illinois.

The estimated maximum surface water concentration is somewhat larger than the mean concentration. The mass transport simulations indicate that the maximum annual mass of TCA-DCA discharged to the Rock River is 1.93×10^{11} ug. The historical lowest daily mean flow for the Rock River is 501 ft³/s (Maurer et al., 1993), or 4.47×10^{11} L/yr assuming that the discharge rate is maintained for 1 year. Thus, the maximum surface water concentration of TCA-DCA during the 30-year period is 0.4 ug/l, which is below the ARARs and the typical analytical detection limit for TCA.

C.5 Limited Action Alternative

Simulations for the Limited Action alternative show that TCA concentrations in groundwater fall below 200 ug/L within 300 years if the source areas are not remediated, and within 110 years if the sources are removed. Modeling for the Limited Action Alternative involved the four pumping nodes at location PW4 (Figure 11). The PW4 pumping node locations were chosen to be downgradient of the RAL concentration contour (650 ug/l) for TCA in the calibrated transport model. The purpose of PW4 is to protect downgradient groundwater users from exposure to concentrations greater than the RAL. PW4 has a total modeled capacity of 1,000 gallons per minute (gpm). Future transport simulations for the Limited Action Alternative were conducted

using this pumping rate and the source area cleanup times in Table 2. Unit well pumping for 1993 was also incorporated in the simulations.

C.5.1 Sources Not Remediated (Limited Action)

Figure 11 shows the simulated TCA-DCA concentrations in Layer 6 after 290 years, assuming that the modeled source areas are not remediated. A small area of TCA-DCA greater than 200 ug/L occurs approximately 2,000 feet north of UW35. This area appears as a small speck in Figure 11. Within 300 years, concentrations fall below 200 ug/L (Figure 12). TCA-DCA concentrations are less than 200 ug/L in other layers.

C.5.2 Sources Remediated (Limited Action)

Figure 13 shows the simulated TCA-DCA concentrations after 100 years, assuming that the modeled source areas are remediated according to the cleanup times listed in Table 2. A small area of contamination greater than 200 ug/L is present in the unconsolidated Valley Fill approximately 1,500 feet northeast of UW35. After 110 years (Figure 14), groundwater concentrations fall below 200 ug/L.

C.6 Remediate Groundwater to MCLs

Contaminant transport simulations for the MCL Alternative indicate that more than 50 years of pumping at a rate of over 5,300 gpm is needed to remediate the entire groundwater plume to the MCL for TCA (200 ug/l). Five sets of pumping nodes, PW1 through PW3, PW5 and PW6, were used to simulate the full-scale remediation of the contaminant plume; PW4 was not used in the simulations for the MCL Alternative. Future transport simulations were conducted using the source area cleanup times listed in Table 2, the pumping rates listed in Table 4, and 1993 unit well fluxes. See Table 5 for a summary of all of the wells in the pumping scheme.

C.6.1 Sources Not Remediated (MCL)

Figure 15 shows the simulated TCA-DCA concentrations in Layer 6 after 260 years, assuming that the modeled source areas are not remediated. A small area of TCA-DCA greater than 200 ug/L occurs approximately 2,100 feet north of UW35 (visible as a small speck in Figure 15). Within 270 years, concentrations fall below 200 ug/L (Figure 16). TCA-DCA concentrations are less than 200 ug/L in the other layers.

C.6.2 Sources Remediated (MCL)

Figure 17 shows the simulated TCA-DCA concentrations after 50 years, assuming that the modeled source areas are remediated according to the cleanup times listed in Table 2. A small area of contamination greater than 200 ug/L is present in the dolomite east of PW5. Within 60 years (Figure 18), groundwater concentrations fall below 200 ug/L.

References for Appendix C

CDM (Camp Dresser & McKee Inc.). 1994. Draft Final. Remedial Investigation Report. Southeast Rockford Groundwater Contamination Study. November.

Maurer, J.C., T.E. Richards, J.K. LaTour, and R.H. Coupe. 1993. Water Resources Data Illinois, Water Year 1992. Volume 1. Illinois Except Illinois River Basin. U.S. Geological Survey Water-Data Report IL-92-1.

Table 3
Simulated TCA-DCA Mass Discharge for No Action Alternative

30-Year Mean	Sources Not Remediated (µg)	Sources Remediated (µg)
Rock River	104.6 x 10 ⁹	105.9 x 10 ⁹
UW35	44.03 x 10 ⁹	43.16 X 10 ⁹
UW34	0.07698 x 10 ⁹	0
30-Year Total		
Rock River*	3,138 x 10 ⁹ (70.3%)	3,178 x 10 ⁹ (71.0%)
UW35*	1,321 x 10 ⁹ (29.6%)	1,295 x 10 ⁹ (29.0%)
UW34*	2.310 x 10 ⁹ (0.1%)	0
50-Year Mean		
Rock River	99.90 x 10 ⁹	94.24 x 10 ⁹
UW35	48.03 x 10 ⁹	44.94 x 10 ⁹
UW34	0.2360 x 10 ⁹	0.07109 x 10 ⁹
50-Year Total		
Rock River*	4,995 x 10 ⁹ (67.4%)	4,712 x 10 ⁹ (67.7%)
UW35*	2,402 x 10 ⁹ (32.4%)	2,248 x 10 ⁹ (32.3%)
UW34*	11.80 x 10 ⁹ (0.2%)	3.554 x 10 ⁹ (<0.1%)
30- and 50-Year Max to River	178.7 x 10 ⁹	193.2 x 10 ⁹

*Percent of total mass removed in parentheses

Note: River mass includes invoked RISI nodes

Table 4
Remediation Pumping Wells

Location	Number of Nodes	Total Pumping Rate (gal/min)
PW1	4	1,332
PW2	5	1,665
PW3	4	1,000
PW4*	4	1,000
PW5	4	1,000
PW6	5	350

*Limited Action Alternative only

Table 5
Well Design for all Pumping Wells in the Proposed Extraction Network

	Model	Pumping Depth (ft BGL)			Pumping Rate	Horizontal Distance from Previous Node (ft)
	Ground Elev. (ft)	Top	Base	Interval		
PW1 Node						
1116	690.33	30.09	90.25	60.17	333	0.0
113	691.00	30.25	90.75	60.50	333	649.5
1119	690.84	30.21	90.63	60.42	333	1,249.3
35	690.44	30.11	90.33	60.22	333	519.6
PW1 Total					1,332	
PW2 Node						
1114	727.37	37.77	113.30	75.53	333	0.0
226	732.13	39.72	119.17	79.45	333	667.2
190	736.65	41.60	124.81	83.20	333	705.6
154	739.06	43.05	129.14	86.09	333	894.5
119	743.52	43.38	130.14	86.76	333	1,133.3
PW2 Total					1,665	
PW3 Node						
1113	749.76	44.81	134.43	89.62	250	0.0
231	749.95	45.51	136.52	91.01	250	585.5
1112	750.00	44.24	132.70	88.47	250	801.0
159	750.92	40.51	121.53	81.02	250	887.1
PW3 Total					1,000	
PW4 Node*						
161	769.45	99.09	185.24	86.16	250	0.0
197	757.93	61.45	153.64	92.18	250	790.6
234	750.75	113.06	183.39	70.33	250	791.2
273	750.00	112.50	181.24	68.74	250	790.7
PW4 Total					1,000	
PW5 Node						
1111	763.37	105.60	185.84	80.23	250	0.0
1110	767.22	91.32	178.81	87.49	250	587.0

Table 5 (continued)
Well Design for all Pumping Wells in the Proposed Extraction Network

	Model	Pumping Depth (ft BGL)			Pumping Rate	Horizontal Distance from Previous Node (ft)
	Ground Elev. (ft)	Top	Base	Interval		
1109	775.87	84.20	178.72	94.52	250	476.8
1108	786.52	79.05	180.88	101.82	250	609.5
PW5 Total					1,000	
PW6 Node						
1104	810.00	98.04	203.81	105.77	70	0.0
1105	810.00	119.21	216.71	97.50	70	363.7
1106	810.00	81.01	191.64	110.63	70	455.9
1107	810.00	64.68	184.68	120.00	70	425.8
1103	810.00	57.83	180.84	123.01	70	453.3
PW6 Total					350	

*For Limited Action Alternative only

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SITE NAME	S E ROCKFORD GROUNDWATER
DOC ID #	140911
DOCUMENT VARIATION	<u> X </u> COLOR OR <u> </u> RESOLUTION
PRP	S E ROCKFORD GROUNDWATER
PHASE	COR/REM
OPERABLE UNITS	
LOCATION	Box # <u> </u> Folder # <u> </u> Subsection <u> K8 </u>
PHASE (AR DOCUMENTS ONLY)	<u> </u> Remedial <u> </u> Removal <u> </u> Deletion Docket <u> </u> Original <u> </u> Update # <u> </u> Volume <u> </u> of <u> </u>
COMMENT(S)	



Appendix D

Appendix D

Calculation of Residual Risk

Appendix D

Calculation of Residual Risk

Summary

Risks were evaluated for on the following two hypothetical residences:

- Hypothetical Residence #1 includes all chemicals detected within the entire study area, in at least 5 percent of the samples, regardless of concentration.
- Hypothetical Residence #3 includes all chemicals detected within the residential study area regardless of concentration.

The chemicals of concern evaluated for each residence are presented in Table D-1.

Within these scenarios, four different exposure pathways were evaluated: the ingestion pathway, dermal pathway, inhalation of household air, and inhalation of volatiles while showering (both during and after the shower).

If available, the MCL/IGWPA Class I Standards were used as the exposure point concentration. In the absence of an MCL, the lower of the maximum detected concentration or risk-based concentration was used as the exposure point concentration. Table D-2 presents the exposure point concentrations.

The following toxicity values were obtained for every chemical: the oral reference dose (RfDo), the inhalation reference dose (RfDi), the oral cancer potency slope (CPSo), and inhalation cancer potency slope (CPSi), using the Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST). Table D-3 presents the toxicity values used in this evaluation.

The RfDo values for 1,1,1-Trichloroethane and Naphthalene have been withdrawn from the Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables as of March 1995.

The permeability constant for *cis*-1,2-Trichloroethane was based on the value obtained for *trans*-1,2-Dichloroethane. Permeability constants for 2-Methylphenol, 4-Methylphenol, and 2,4-Dimethylphenol were based on values obtained for phenol and the permeability constant for 2-Methylnaphthalene was based on the value obtained for Naphthalene.

The Inhalation Reference Dose values for 1,1,1-Trichloroethane, Ethylbenzene, and Xylene have been withdrawn from the Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables as of March 1995.

The MCL (Maximum Contaminant Level) was obtained from Table 4-8: Groundwater Organic Compounds - Range and Frequency of Detection from Remedial Investigation Report Southeast Rockford Groundwater Contamination Study, CDM, May, 1994.

Risks were estimated for each hypothetical residence based on the same exposure models presented in Remedial Investigation Report, Southeast Rockford Groundwater Contamination Study (CDM 1994). An explanation of each model is presented in this report. Tables D-4 and D-5 present the estimation of household air and shower air concentrations, respectively. Table D-6 presents the exposure point concentrations used to estimate risk.

Total cancer risks for both hypothetical residences only slightly exceeded the EPA acceptable risk range of $1.0\text{E-}06$ to $1.0\text{E-}04$. Cancer risks for hypothetical residence #1 were estimated to be $2.2\text{E-}04$; cancer risks for hypothetical residence #2 were estimated to be $1.3\text{E-}04$. The major contributor to cancer risk for both was 1,1-dichloroethene.

Total hazard index for both hypothetical residences exceeded the hazard index of 1. The hazard index for residence #1 was estimated at 10; the hazard index for residence #2 was estimated at 1.8. The major contributors to hazard index were xylene and toluene for hypothetical residences #1 and 1,1,1-trichloroethane and 1,1-dichloroethane for hypothetical residence #2. Several semi-volatiles also contributed significantly to the total hazard index for residence #1. Table 2-1 in Section 2, presents a summary of hazard index and risks associated with exposure to MCLS and maximum or risk-based concentrations.

Alternate Cleanup Levels

Estimated cancer risks and total hazard index exceeded the acceptable cancer and noncancer limits for both hypothetical residences when residual concentrations were assumed equal to MCLs and maximum or risk-based concentrations (in the absence of MCLs). For this reason, alternative cleanup levels were developed.

The calculation of alternative cleanup levels was an iterative process of reducing concentrations until risks and total hazard index were within acceptable limits. Chemicals with the highest MCLs, maximum or risk-based concentrations which contributed most significantly to cancer risk or hazard index were targeted first. Tables 2-4 and 2-5 in Section 2 present alternative cleanup levels associated with cancer risks that do not exceed $1\text{E-}04$ and total hazard indices that do not exceed 1.0. The adjusted hazard indices that do not exceed 1.0. The adjusted concentration are presented in bold and italics. Support documentation for this exercise is presented in this Appendix.

TABLE D-1
CHEMICALS OF CONCERN
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

CHEMICAL OF CONCERN HYPOTHETICAL RESIDENCE #1	CHEMICAL OF CONCERN HYPOTHETICAL RESIDENCE #2
Vinyl Chloride	Methylene Chloride
Chloroethane	1,1-Dichloroethene
Methylene Chloride	1,1-Dichloroethane
1,1-Dichloroethene	Cis-1,2-Dichloroethene
1,1-Dichloroethane	trans-1,2-Dichloroethene
Cis-1,2-Dichloroethene	Chloroform
trans-1,2-Dichloroethene	1,2-Dichloroethane
Chloroform	1,1,1-Trichloroethane
1,2-Dichloroethane	Trichloroethene
2-Butanone	Tetrachloroethene
1,1,1-Trichloroethane	
1,2-Dichloropropane	
Trichloroethene	
Benzene	
4-Methyl-2-Pentanone	
Tetrachloroethene	
Toluene	
Ethylbenzene	
Xylene	
1,2-Dichlorobenzene	
2-Methylphenol	
4-Methylphenol	
2,4-Dimethylphenol	
Naphthalene	
2-Methylnaphthalene	
Di-n-Butylphthalate	
bis(2-Ethylhexyl)Phthalate	

cocsum.xls

**TABLE D-2 - EXPOSURE POINT CONCENTRATIONS
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION**

CHEMICAL OF CONCERN	Exposure Conc. (mg/l)
<u>Volatile Organics</u>	
Vinyl Chloride	0.002(1)
Chloroethane	0.500(2)
Methylene Chloride	0.005(1)
1,1-Dichloroethene	0.007(1)
1,1-Dichloroethane	0.8 (3)
Cis-1,2-Dichloroethene	0.07(1)
trans-1,2-Dichloroethene	0.1(1)
Chloroform	0.00015 (3)
1,2-Dichloroethane	0.005(1)
2-Butanone	NA
1,1,1-Trichloroethane	0.2(1)
1,2-Dichloropropane	0.005(1)
Trichloroethene	0.005(1)
Benzene	0.005(1)
4-Methyl-2-Pentanone	NA
Tetrachloroethene	0.005(1)
Toluene	1(1)
Ethylbenzene	0.7(1)
Xylene	10(1)
<u>Semivolatile Organics</u>	
1,2-Dichlorobenzene	0.026(2)
2-Methylphenol	0.100(2)
4-Methylphenol	0.088(2)
2,4-Dimethylphenol	0.054(2)
Naphthalene	0.043(2)
2-Methylnaphthalene	0.005(2)
Di-n-Butylphthalate	0.001(2)
bis(2-Ethylhexyl)Phthalate	0.006(1)

toxval 1a.xls

(1) MCL

(2)Maximum Detected Concentration

(3)Risk-based concentration from RAGS Part B

TABLE D-3 - TOXICITY VALUES
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION SITE

CHEMICAL OF CONCERN	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg *d/mg	CPSi kg*d/mg	MCL (mg/l)	Permeab. Constant (1)
<u>Volatile Organics</u>						
Vinyl Chloride	-	-	1.9E+00	3.0E-01	0.002	7.3E-03
Chloroethane	4.0E-01	2.9E+00	-	-	NA	8.0E-03
Methylene Chloride	6.0E-02	8.6E-01	7.5E-03	1.64E-03	0.005	4.5E-03
1,1-Dichloroethene	9.0E-03	-	6.0E-01	1.75E-01	0.007	1.6E-02
1,1-Dichloroethane	1.0E-01	1.4E-01	-	-	NA	8.9E-03
Cis-1,2-Dichloroethene	1.0E-02	-	-	-	0.07	1.0E-02 (4)
trans-1,2-Dichloroethene	2.0E-02	-	-	-	0.1	1.0E-02
Chloroform	1.0E-02	-	6.1E-03	8.1E-02	NA	8.9E-03
1,2-Dichloroethane	-	2.9E-03	9.1E-02	9.1E-02	0.005	5.3E-03
2-Butanone	-	-	-	-	NA	1.1E-03
1,1,1-Trichloroethane	9.0E-02 (3)	2.9E-01 (3)	-	-	0.2	5.7E-01
1,2-Dichloropropane	-	1.1E-03	6.8E-02	-	0.005	1.0E-02
Trichloroethene	6.0E-03 (2)	-	1.1E-02 (3)	6.0E-03 (2)	0.005	1.6E-02
Benzene	-	1.7E-03	2.9E-02	2.9E-02	0.005	2.1E-02
4-Methyl-2-Pentanone	-	-	-	-	NA	-
Tetrachloroethene	1.0E-02	-	5.2E-02	2.0E-03	0.005	4.8E-02
Toluene	2.0E-01	1.1E-01	-	-	1	4.5E-02
Ethylbenzene	1.0E-01	2.9E-01 (3)	-	-	0.7	7.4E-02
Xylene	2.0E+00	2.0E-01 (3)	-	-	10	8.0E-02
<u>Semivolatile Organics</u>						
1,2-Dichlorobenzene	9.0E-02	4.0E-02	-	-	NA	6.10E-02
2-Methylphenol	5.0E-02	-	-	-	NA	5.5E-03 (5)
4-Methylphenol	5.0E-03	-	-	-	NA	5.5E-03 (5)
2,4-Dimethylphenol	2.0E-02	-	-	-	NA	5.5E-03 (5)
Naphthalene	4.0E-02 (3)	-	-	-	NA	6.9E-02
2-Methylnaphthalene	4.0E-02 (8)	-	-	-	NA	6.9E-02 (6)
Di-n-Butylphthalate	1.0E-01	-	-	-	0.006	3.30E-02
bis(2-Ethylhexyl)Phthalate	2.0E-02	-	1.4E-02	-	0.006	4.8E-03

toxval 1.xls

(1): Permeability Constant is based on the Estimated value; recommended by EPA

(2): ECAO Provisional value

(3): Value withdrawn from IRIS or HEAST as of 3/95

(4): Permeability constant for trans-1,2-Dichloroethene

(5): Permeability constant for phenol

(6): Permeability constant for Naphthalene

(7) Risk-based concentration per RAGS Part B

(8) RfD for naphthalene

TABLE D-4
EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

Chemical of Concern	Household Air (CA) Exposure Point Concentrations of Groundwater Origin						
	WHF (l/day)	CW (mg/l)	f (unitless)	HV (m ³)	ER (day ⁻¹)	MC (unitless)	CA (mg/m ³)
<u>Volatile Organics</u>							
Vinyl Chloride	720	0.002	0.9	180	15	0.5	0.0010
Chloroethane	720	0.5	0.9	180	15	0.5	0.24
Methylene Chloride	720	0.005	0.9	180	15	0.5	0.0024
1,1-Dichloroethene	720	0.0070	0.9	180	15	0.5	0.0034
1,1-Dichloroethane	720	0.8	0.9	180	15	0.5	0.4
Cis-1,2-Dichloroethene	720	0.07	0.9	180	15	0.5	0.034
Trans-1,2-Dichloroethene	720	0.1	0.9	180	15	0.5	0.048
Chloroform	720	0.00015	0.9	180	15	0.5	0.00007
1,2-Dichloroethane	720	0.005	0.9	180	15	0.5	0.0024
2-Butanone	720	NA	0.9	180	15	0.5	NA
1,1,1-Trichloroethane	720	0.2	0.9	180	15	0.5	0.096
1,2-Dichloropropane	720	0.005	0.9	180	15	0.5	0.002
Trichloroethylene	720	0.005	0.9	180	15	0.5	0.0024
Benzene	720	0.005	0.9	180	15	0.5	0.0024
4-Methyl-2-Pentanone	720	NA	0.9	180	15	0.5	NA
Tertachloroethene	720	0.005	0.9	180	15	0.5	0.0024
Toluene	720	1.0	0.9	180	15	0.5	0.48
Ethylbenzene	720	0.7	0.9	180	15	0.5	0.34
Xylene	720	10	0.9	180	15	0.5	4.8
<u>Semivolatile Organics</u>							
1,2-Dichlorobenzene	720	0.026	0.9	180	15	0.5	0.012
2-Methylphenol	720	0.100	0.9	180	15	0.5	0.048
4-Methylphenol	720	0.088	0.9	180	15	0.5	0.042
2,4-Dimethylphenol	720	0.054	0.9	180	15	0.5	0.026
Napthalene	720	0.043	0.9	180	15	0.5	0.021
2-Methylnapthalene	720	0.005	0.9	180	15	0.5	0.0024
Di-n-butylphthalate(1)	720	0.001	0.9	180	15	0.5	0.0029
bis(2-Ethylhexyl)Phthalate	720	0.006	0.9	180	15	0.5	0.0029

opt1-ep.xls

(1) Risk-based concentration for di-n-octyl phthalate

CA = (WHF * CW * f) / (HV * ER * MC)

Table D-5
EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

Shower Air Exposure Point Concentrations of Groundwater Origin (During and After Showering)							
Chemical of Concern	CW	f	Fw	t1	Va	CA 1 (*)	CA max or CA 2 (**)
<u>Volatile Organics</u>							
Vinyl Chloride	0.002	0.9	800	0.2	10	0.0144	0.029
Chloroethane	0.5	0.9	800	0.2	10	3.6000	7.2
Methylene Chloride	0.005	0.9	800	0.2	10	0.0360	0.072
1,1-Dichloroethene	0.007	0.9	800	0.2	10	0.0504	0.10
1,1-Dichloroethane	0.8	0.9	800	0.2	10	5.760	12
Cis-1,2-Dichloroethene	0.07	0.9	800	0.2	10	0.504	1.0
Trans-1,2-Dichloroethene	0.1	0.9	800	0.2	10	0.720	1.4
Chloroform	0.00015	0.9	800	0.2	10	0.0011	0.0022
1,2-Dichloroethane	0.005	0.9	800	0.2	10	0.036	0.072
2-Butanone	NA	0.9	800	0.2	10	NA	NA
1,1,1-Trichloroethane	0.2	0.9	800	0.2	10	1.4400	2.9
1,2-Dichloropropane	0.005	0.9	800	0.2	10	0.0360	0.072
Trichloroethylene	0.005	0.9	800	0.2	10	0.0360	0.072
Benzene	0.005	0.9	800	0.2	10	0.036	0.072
4-Methyl-2-Pentanone	NA	0.9	800	0.2	10	NA	NA
Tertachloroethene	0.005	0.9	800	0.2	10	0.036	0.072
Toluene	1	0.9	800	0.2	10	7.2000	14
Ethylbenzene	0.7	0.9	800	0.2	10	5.0400	10
Xylene	10	0.9	800	0.2	10	72.0000	144
<u>Semivolatile Organics</u>							
1,2-Dichlorobenzene	0.026	0.9	800	0.2	10	0.1872	0.374
2-Methylphenol	0.1	0.9	800	0.2	10	0.7200	1.4
4-Methylphenol	0.088	0.9	800	0.2	10	0.634	1.3
2,4-Dimethylphenol	0.054	0.9	800	0.2	10	0.395	0.79
Napthalene	0.043	0.9	800	0.2	10	0.310	0.62
2-Methylnapthalene	0.005	0.9	800	0.2	10	0.036	0.072
Di-n-butylphthalate	0.001	0.9	800	0.2	10	0.0072	0.014
bis(2-Ethylhexyl)Phthalate	0.006	0.9	800	0.2	10	0.0432	0.086

opt1-ep.xls

Derived from shower air model as presented in Table 6-12

CA1 = CA Max / 2

CA2 = CA Max

CA Max = (CW * f * Fw * t1) / Va

TABLE D-6
EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

CHEMICAL OF CONCERN	House Groundwater EPCs Ingestion Exposures (mg/l)	House Groundwater EPCs Dermal Exposures (mg/l)	Household Air EPCs of Groundwater Origin (mg/m ³)	"During Shower" Air EPCs of Groundwater Origin (mg/m ³)	"After Shower" Air EPCs of Groundwater Origin (mg/m ³)
Vinyl Chloride	0.002	0.002	0.001	0.014	0.029
Chloroethane	0.5	0.5	0.24	3.6	7.2
Methylene Chloride	0.005	0.005	0.0024	0.036	0.072
1,1-Dichloroethene	0.007	0.007	0.0034	0.05	0.10
1,1-Dichloroethane	0.8	0.8	0.4	6	12
Cis-1,2-Dichloroethene	0.07	0.07	0.034	0.5	1.0
Trans-1,2-Dichloroethene	0.10	0.10	0.048	0.72	1.4
Chloroform	0.00015	0.00015	0.00007	0.00108	0.00216
1,2-Dichloroethane	0.005	0.005	0.0024	0.036	0.072
2-Butanone	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	0.20	0.20	0.096	1.44	2.9
1,2-Dichloropropane	0.005	0.005	0.0024	0.036	0.072
Trichloroethylene	0.005	0.005	0.0024	0.036	0.072
Benzene	0.005	0.005	0.0024	0.036	0.072
4-Methyl-2-Pentanone	NA	NA	NA	NA	NA
Tetrachloroethene	0.005	0.005	0.0024	0.036	0.072
Toluene	1.0	1.0	0.48	7.2	14
Ethylbenzene	0.7	0.7	0.336	5.0	10
Xylene	10	10	4.8	72	144
<i>Semivolatile Organics</i>					
1,2-Dichlorobenzene	0.026	0.026	0.012	0.187	0.37
2-Methylphenol	0.10	0.10	0.048	0.72	1.44
4-Methylphenol	0.088	0.088	0.042	0.63	1.3
2,4-Dimethylphenol	0.054	0.054	0.026	0.40	0.78
Napthalene	0.043	0.043	0.021	0.31	0.62
2-Methylnapthalene	0.005	0.005	0.0024	0.036	0.072
Di-n-butylphthalate	0.001	0.001	0.0029	0.007	0.014
bis(2-Ethylhexyl)Phthalate	0.006	0.006	0.0029	0.043	0.086

opt1-ep.xls

**INGESTION OF CHEMICALS IN POTABLE GROUNDWATER
HYPOTHETICAL RESIDENCE #1
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI \text{ (mg/kg/day)} = (CW * IR * EF * ED) / (BW * AT)$$

Non-Carcinogenic Risk:

$$\text{Hazard Quotient} = \text{Chronic Daily Intake (mg/kg/day)} / \text{RfD (mg/kg/day)}$$

$$\text{Hazard Index} = \text{Sum (Chemical-Specific Hazard Quotients)}$$

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CW = Chemical Concentration in Water (mg/kg)

IR = Water Ingestion Rate (liters/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

Carcinogenic Risk:

$$\text{Chemical-Specific Cancer Risk} = \text{Chronic Daily Intake (mg/kg/day)} * \text{Cancer Slope Factor (mg/kg/day)}^{-1}$$

$$\text{Excess Lifetime Cancer Risk} = \text{Sum (Chemical-Specific Cancer Risk)}$$

Chemical	Chemical Conc. in Water * (mg/l)	Ingest. Rate (l/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
						Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
<i>Volatile Organics</i>															
Vinyl Chloride	0.002	2	350	30	70	10,950	25,550	5.5E-05	2.3E-05	-	1.9E+00	-	-	4.5E-05	41%
Chloroethane	0.500	2	350	30	70	10,950	25,550	1.4E-02	5.9E-03	4.0E-01	-	3.4E-02	2%	-	-
Methylene Chloride	0.0050	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-02	7.5E-03	2.3E-03	0%	4.4E-07	0%
1,1-Dichloroethene	0.0070	2	350	30	70	10,950	25,550	1.9E-04	8.2E-05	9.0E-03	6.0E-01	2.1E-02	1%	4.9E-05	45%
1,1-Dichloroethane	0.80	2	350	30	70	10,950	25,550	2.2E-02	9.4E-03	1.0E-01	-	2.2E-01	12%	-	-
Cis-1,2-Dichloroethene	0.070	2	350	30	70	10,950	25,550	1.9E-03	8.2E-04	1.0E-02	-	1.9E-01	10%	-	-
Trans-1,2-Dichloroethene	0.100	2	350	30	70	10,950	25,550	2.7E-03	1.2E-03	2.0E-02	-	1.4E-01	7%	-	-
Chloroform	0.00015	2	350	30	70	10,950	25,550	4.1E-06	1.8E-06	1.0E-02	6.1E-03	4.1E-04	0%	1.1E-08	0%
1,2-Dichloroethane	0.0050	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	9.1E-02	-	-	5.3E-06	5%
1,1,1-Trichloroethane	0.200	2	350	30	70	10,950	25,550	5.5E-03	2.3E-03	9.0E-02	-	6.1E-02	3%	-	-
1,2-Dichloropropane	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	6.8E-02	-	-	4.0E-06	4%
Trichloroethene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-03	1.1E-02	2.3E-02	1%	6.5E-07	1%
Benzene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	2.9E-02	-	-	1.7E-06	2%
Tetrachloroethene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	1.0E-02	5.20E-02	1.4E-02	1%	3.1E-06	3%
Toluene	1	2	350	30	70	10,950	25,550	2.7E-02	1.2E-02	2.0E-01	-	1.4E-01	7%	-	-
Ethylbenzene	0.7	2	350	30	70	10,950	25,550	1.9E-02	8.2E-03	1.0E-01	-	1.9E-01	10%	-	-
Xylene	10	2	350	30	70	10,950	25,550	2.7E-01	1.2E-01	2.0E+00	-	1.4E-01	7%	-	-
<i>Semivolatile Organics</i>															
1,2-Dichlorobenzene	0.026	2	350	30	70	10,950	25,550	7.1E-04	3.1E-04	9.0E-02	-	7.9E-03	0%	-	-
2-Methylphenol	0.100	2	350	30	70	10,950	25,550	2.7E-03	1.2E-03	5.0E-02	-	5.5E-02	3%	-	-
4-Methylphenol	0.088	2	350	30	70	10,950	25,550	2.4E-03	1.0E-03	5.0E-03	-	4.8E-01	26%	-	-
2,4-Dimethylphenol	0.054	2	350	30	70	10,950	25,550	1.5E-03	6.3E-04	2.0E-02	-	7.4E-02	4%	-	-
Naphthalene	0.043	2	350	30	70	10,950	25,550	1.2E-03	5.0E-04	4.0E-02	-	2.9E-02	2%	-	-
2-Methylnaphthalene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	4.0E-02	-	3.4E-03	0%	-	-
Di-n-Butylphthalate	0.001	2	350	30	70	10,950	25,550	2.7E-05	1.2E-05	1.0E-01	-	2.7E-04	0%	-	-
bis(2-Ethylhexyl)Phthalate	0.006	2	350	30	70	10,950	25,550	1.6E-04	7.0E-05	2.0E-02	1.4E-02	8.2E-03	0%	9.9E-07	1%
Hazard Index =												1.8E+00	100%		
Excess Lifetime Cancer Risk =												1.1E-04	100%		

DERMAL CONTACT WITH CHEMICALS IN GROUNDWATER (NONSTEADY STATE MODEL)
HYPOTHETICAL RESIDENCE #1
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES

Calculations:

$$AD \text{ (mg/kg/day)} = [(2 * CW * CF * PC * \text{Square root}((6 * T * ET/PI)) * (SA * EF * ED)) / (BW * AT)]$$

Non-Carcinogenic Risk:

$$\text{Hazard Quotient} = \text{Absorbed Dose (mg/kg/day)} / \text{RfD (mg/kg/day)}$$

$$\text{Hazard Index} = \text{Sum (Chemical-Specific Hazard Quotients)}$$

Carcinogenic Risk:

$$\text{Chemical-Specific Cancer Risk} = \text{Absorbed Dose (mg/kg/day)} * \text{Cancer Slope Factor (mg/kg/day)}^{-1}$$

$$\text{Excess Lifetime Cancer Risk} = \text{Sum (Chemical-Specific Cancer Risk)}$$

Where:

AD = Absorbed Dose (mg/kg/day)

CW = Chemical Concentration in Water (mg/l)

CF = Volumetric Conversion Factor for Water (1 liter/1,000 cm³)

SA = Skin Surface Available for Contact (cm²)

PC = Chemical-Specific Dermal Permeability Constant (cm/hr)

T = Lag time (hours)

ET = Exposure Time (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

Chemical	Chemical Conc. in Water (mg/l)	Conv. Factor (1 l/1,000 cm^3)	Permeab. Constant (cm/hour)	T (hours)	Exposure Time (hrs/days)	Skin Surface Area (cm^2)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Absorbed Dose (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day)^-1	Non-Carcinogenic Risk		Carcinogenic Risk						
										Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk					
<i>Volatile Organics</i>																								
Vinyl Chloride	0.002	1.0E-03	7.3E-03	2.1E-01	0.2	19,400	350	30	70	10,950	25,550	2.2E-06	9.4E-07	-	1.9E+00	-	-	1.8E-06	18%					
Chloroethane	0.500	1.0E-03	8.0E-03	2.2E-01	0.2	19,400	350	30	70	10,950	25,550	6.2E-04	2.6E-04	4.0E-01	-	1.5E-03	0%	-	-					
Methylene Chloride	0.0050	1.0E-03	4.5E-03	2.9E-01	0.2	19,400	350	30	70	10,950	25,550	4.0E-06	1.7E-06	6.0E-02	7.5E-03	6.6E-05	0%	1.3E-08	0%					
1,1-Dichloroethene	0.0070	1.0E-03	1.6E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	2.1E-05	9.2E-06	9.0E-03	6.0E-01	2.4E-03	0%	5.5E-06	55%					
1,1-Dichloroethane	0.80	1.0E-03	8.9E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.4E-03	5.9E-04	1.0E-01	-	1.4E-02	2%	-	-					
Cis-1,2-Dichloroethene	0.070	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.3E-04	5.7E-05	1.0E-02	-	1.3E-02	2%	-	-					
Trans-1,2-Dichloroethene	0.100	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-04	8.2E-05	2.0E-02	-	9.6E-03	1%	-	-					
Chloroform	0.00015	1.0E-03	8.9E-03	4.7E-01	0.2	19,400	350	30	70	10,950	25,550	3.0E-07	1.3E-07	1.0E-02	6.1E-03	3.0E-05	0%	7.9E-10	0%					
1,2-Dichloroethane	0.0050	1.0E-03	5.3E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	5.1E-06	2.2E-06	-	9.1E-02	-	-	2.0E-07	2%					
1,1,1-Trichloroethane	0.200	1.0E-03	5.7E-01	5.7E-01	0.2	19,400	350	30	70	10,950	25,550	2.8E-02	1.2E-02	9.0E-02	-	3.1E-01	49%	-	-					
1,2-Dichloropropane	0.005	1.0E-03	1.0E-02	4.3E-01	0.2	19,400	350	30	70	10,950	25,550	1.1E-05	4.6E-06	-	6.8E-02	-	-	3.1E-07	3%					
Trichloroethene	0.005	1.0E-03	1.6E-02	5.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.4E-06	6.0E-03	1.1E-02	3.2E-03	1%	9.2E-08	1%					
Benzene	0.005	1.0E-03	2.1E-02	2.6E-01	0.2	19,400	350	30	70	10,950	25,550	1.8E-05	7.5E-06	-	2.9E-02	-	-	2.2E-07	2%					
Tetrachloroethene	0.005	1.0E-03	4.80E-02	9.0E-01	0.2	19,400	350	30	70	10,950	25,550	7.5E-05	3.2E-05	1.0E-02	5.20E-02	7.5E-03	1%	1.7E-06	17%					
Toluene	1	1.0E-03	4.50E-02	3.2E-01	0.2	19,400	350	30	70	10,950	25,550	8.4E-03	3.6E-03	2.0E-01	-	4.2E-02	6%	-	-					
Ethylbenzene	0.7	1.0E-03	7.4E-02	3.9E-01	0.2	19,400	350	30	70	10,950	25,550	1.1E-02	4.6E-03	1.0E-01	-	1.1E-01	16%	-	-					
Xylene	10	1.0E-03	8.0E-02	3.9E-01	0.2	19,400	350	30	70	10,950	25,550	1.6E-01	7.0E-02	2.0E+00	-	8.2E-02	13%	-	-					
<i>Semivolatile Organics</i>																								
1,2-Dichlorobenzene	0.026	1.0E-03	6.1E-02	6.9E-01	0.2	19,400	350	30	70	10,950	25,550	4.3E-04	1.9E-04	9.0E-02	-	4.8E-03	1%	-	-					
2-Methylphenol	0.100	1.0E-03	5.5E-03	3.3E-01	0.2	19,400	350	30	70	10,950	25,550	1.0E-04	4.4E-05	5.0E-02	-	2.1E-03	0%	-	-					
4-Methylphenol	0.088	1.0E-03	5.5E-03	3.3E-01	0.2	19,400	350	30	70	10,950	25,550	9.1E-05	3.9E-05	5.0E-03	-	1.8E-02	3%	-	-					
2,4-Dimethylphenol	0.054	1.0E-03	5.5E-03	4.9E-01	0.2	19,400	350	30	70	10,950	25,550	6.8E-05	2.9E-05	2.0E-02	-	3.4E-03	1%	-	-					
Naphthalene	0.043	1.0E-03	6.9E-02	5.3E-01	0.2	19,400	350	30	70	10,950	25,550	7.1E-04	3.0E-04	4.0E-02	-	1.8E-02	3%	-	-					
2-Methylnaphthalene	0.005	1.0E-03	4.0E-02	1.1E-01	0.2	19,400	350	30	70	10,950	25,550	2.2E-05	9.3E-06	4.0E-02	-	5.4E-04	0%	-	-					
Di-n-Butylphthalate	0.001	1.0E-03	3.3E-02	4.3E+00	0.2	19,400	350	30	70	10,950	25,550	2.2E-05	9.6E-06	1.0E-01	-	2.2E-04	0%	-	-					
bis(2-Ethylhexyl)Phthalate	0.0060	1.0E-03	4.8E-03	2.1E+01	0.2	19,400	350	30	70	10,950	25,550	4.3E-05	1.9E-05	2.0E-02	1.4E-02	2.2E-03	0%	2.6E-07	3%					
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Hazard Index = 6.5E-01 100%

Excess Lifetime Cancer Risk = 1.0E-05 100%

**INHALATION OF AIRBORNE GROUNDWATER CHEMICALS IN HOUSEHOLD AIR
HYPOTHETICAL RESIDENCE #1
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI (mg/kg/day) = (CA * IR * EF * ED) / BW * AT$$

$$CA = (WHF * CW * f) / (HV * ER * MC)$$

Non-Carcinogenic Risk:

$$Hazard\ Quotient = Chronic\ Daily\ Intake\ (mg/kg/day) / RfD\ (mg/kg/day)$$

$$Hazard\ Index = Sum\ (Chemical-Specific\ Hazard\ Quotients)$$

Carcinogenic Risk:

$$Chemical-Specific\ Cancer\ Risk = Chronic\ Daily\ Intake\ (mg/kg/day) * Cancer\ Slope\ Factor\ (mg/kg/day)^{-1}$$

$$Excess\ Lifetime\ Cancer\ Risk = Sum\ (Chemical-Specific\ Cancer\ Risk)$$

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CA = Chemical Concentration in Household Air (mg/m³)

IR = Inhalation Rate (m³/hour)

ER = Exposure Rate (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

WHF = Water Flow Rate in Whole House/Facility (liter/day)

f = Fraction of Contaminant that Volatilizes (unitless)

ER = Air Exchange Rate (changes/day)

MC = Mixing Coefficient (unitless)

Chemical	Chemical Conc. In Household Air (CA) (mg/m ³)	Inhal Rate (m ³ /hour)	Exposure Frequency (days/year)	Exposure Rate (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
							Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
Vinyl Chloride	0.0010	0.6	350	16	30	70	10,950	25,550	1.3E-04	5.4E-05	-	3.0E-01	-	-	1.6E-05	24.1%
Chloroethane	0.2400	0.6	350	16	30	70	10,950	25,550	3.2E-02	1.4E-02	2.86E+00	-	1.1E-02	0.2%	-	-
Methylene Chloride	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	8.57E-01	1.6E-03	3.7E-04	0.0%	2.2E-07	0.3%
1,1-Dichloroethene	0.0034	0.6	350	16	30	70	10,950	25,550	4.4E-04	1.9E-04	-	1.8E-01	-	-	3.3E-05	49.2%
1,1-Dichloroethane	0.4000	0.6	350	16	30	70	10,950	25,550	5.3E-02	2.3E-02	1.43E-01	-	3.7E-01	7.5%	-	-
Cis-1,2-Dichloroethene	0.0336	0.6	350	16	30	70	10,950	25,550	4.4E-03	1.9E-03	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.0480	0.6	350	16	30	70	10,950	25,550	6.3E-03	2.7E-03	-	-	-	-	-	-
Chloroform	0.0001	0.6	350	16	30	70	10,950	25,550	1.3E-05	5.6E-06	-	8.1E-02	-	-	4.6E-07	0.7%
1,2-Dichloroethane	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	2.90E-03	9.1E-02	1.1E-01	2.2%	1.2E-05	18.3%
1,1,1-Trichloroethane	0.0960	0.6	350	16	30	70	10,950	25,550	1.3E-02	5.4E-03	2.9E-01	-	4.4E-02	0.9%	-	-
1,2-Dichloropropane	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	1.14E-03	-	2.8E-01	5.7%	-	-
Trichloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	6.0E-03	-	-	8.1E-07	1.2%
Benzene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	1.71E-03	2.9E-02	1.8E-01	3.8%	3.9E-06	5.8%
Tetrachloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	2.0E-03	-	-	2.7E-07	0.4%
Toluene	0.4800	0.6	350	16	30	70	10,950	25,550	6.3E-02	2.7E-02	1.14E-01	-	5.5E-01	11.3%	-	-
Ethylbenzene	0.3360	0.6	350	16	30	70	10,950	25,550	4.4E-02	1.9E-02	2.86E-01	-	1.5E-01	3.2%	-	-
Xylene	4.8000	0.6	350	16	30	70	10,950	25,550	6.3E-01	2.7E-01	2.00E-01	-	3.2E+00	64.6%	-	-
Semivolatile Organics																
1,2-Dichlorobenzene	0.0120	0.6	350	16	30	70	10,950	25,550	1.6E-03	6.8E-04	5.71E-02	-	2.8E-02	0.6%	-	-
2-Methylphenol	0.0480	0.6	350	16	30	70	10,950	25,550	6.3E-03	2.7E-03	-	-	-	-	-	-
4-Methylphenol	0.0420	0.6	350	16	30	70	10,950	25,550	5.5E-03	2.4E-03	-	-	-	-	-	-
2,4-Dimethylphenol	0.0260	0.6	350	16	30	70	10,950	25,550	3.4E-03	1.5E-03	-	-	-	-	-	-
Naphthalene	0.0210	0.6	350	16	30	70	10,950	25,550	2.8E-03	1.2E-03	-	-	-	-	-	-
2-Methylnaphthalene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	-	-	-	-	-
Di-n-Butylphthalate	0.0029	0.6	350	16	30	70	10,950	25,550	3.8E-04	1.6E-04	-	-	-	-	-	-
bis(2-Ethylhexyl)Phthalate	0.0029	0.6	350	16	30	70	10,950	25,550	3.8E-04	1.6E-04	-	-	-	-	-	-

opt1-ha.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 4.9E+00 100%

Excess Lifetime Cancer Risk = 6.7E-05 100%

**INHALATION OF AIRBORNE GROUNDWATER CHEMICALS IN SHOWER AIR
HYPOTHETICAL RESIDENCE #1
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI (mg/kg/day) = [(CA1 * IR * SP) + (CA2 * IR * ASP)] * (EF * ED) / BW * AT$$

$$CA_{Max} = CW * f * Fw * t1 / Va$$

$$CA1 = CA_{Max}/2$$

$$CA2 = CA_{Max}$$

Non-Carcinogenic Risk:

$$Hazard\ Quotient = Chronic\ Daily\ Intake\ (mg/kg/day) / RfD\ (mg/kg/day)$$

$$Hazard\ Index = Sum\ (Chemical-Specific\ Hazard\ Quotients)$$

Carcinogenic Risk:

$$Chemical-Specific\ Cancer\ Risk = Chronic\ Daily\ Intake\ (mg/kg/day) * Cancer\ Slope\ Factor\ (mg/kg/day)^{-1}$$

$$Excess\ Lifetime\ Cancer\ Risk = Sum\ (Chemical\ Specific\ Cancer\ Risk)$$

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CA1 = Air Concentration During Shower (mg/m³)

IR = Inhalation Rate (m³/hour)

SP = Shower Period (hours/day)

CA2 = Air Concentration After Shower (mg/m³)

ASP = After Shower Period (hours/day)

EF = Exposure Frequency (days/year)

t1 = Time of Shower (hours)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

CW = Average Chemical Concentration in Water (mg/l)

f = Fraction of Contaminant that Volatilizes (unitless)

Fw = Water Flow Rate in Shower (liters/hour)

Va = Bathroom Size (m³)

Chemical	Conc. in Air During Shower (CA1) (mg/m ³)	Conc. in Air After Shower (CA2) (mg/m ³)	Inhal. Rate (m ³ /hr)	Shower Period (hrs/day)	After Shower Period (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
									Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
Vinyl Chloride	0.0144	0.0288	0.6	0.2	0.2	350	30	70	10,950	25,550	7.1E-05	3.0E-05	-	3.0E-01	-	-	9.1E-06	32%
Chloroethane	3.6000	7.2000	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-02	7.6E-03	2.9E+00	-	6.2E-03	0%	-	-
Methylene Chloride	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	8.6E-01	1.6E-03	2.1E-04	0%	1.2E-07	0%
1,1-Dichloroethene	0.0504	0.1008	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-04	1.1E-04	-	1.8E-01	-	-	1.9E-05	65%
1,1-Dichloroethene (✓)	6.0000	12.0000	0.6	0.2	0.2	350	30	70	10,950	25,550	3.0E-02	1.3E-02	1.4E-01	-	2.1E-01	8%	-	-
Cis-1,2-Dichloroethene	0.5040	1.008	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-03	1.1E-03	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.7200	1.044	0.6	0.2	0.2	350	30	70	10,950	25,550	2.9E-03	1.2E-03	-	-	-	-	-	-
Chloroform	0.0011	0.002	0.6	0.2	0.2	350	30	70	10,950	25,550	5.4E-06	2.3E-06	-	8.1E-02	-	-	1.9E-07	1%
1,2-Dichloroethane	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	2.9E-03	9.1E-02	6.1E-02	2%	6.9E-06	24%
1,1,1-Trichloroethane	1.440	2.880	0.6	0.2	0.2	350	30	70	10,950	25,550	7.1E-03	3.0E-03	2.9E-01	-	2.4E-02	1%	-	-
1,2-Dichloropropane	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	1.1E-03	-	1.6E-01	6%	-	-
Trichloroethylene	0.0360	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	6.0E-03	-	-	4.6E-07	2%
Benzene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	1.7E-03	2.9E-02	1.0E-01	4%	2.2E-06	8%
Tetrachloroethene	0.0360	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	2.0E-03	-	-	1.5E-07	1%
Toluene	7.2	14.4	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-02	1.5E-02	1.1E-01	-	3.1E-01	11%	-	-
Ethylbenzene	5.04	10.08	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-02	1.1E-02	2.9E-01	-	8.7E-02	3%	-	-
Xylene	72	144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-01	1.5E-01	2.0E-01	-	1.8E+00	65%	-	-
Semivolatile Organics																		
1,2-Dichlorobenzene	0.1872	0.374	0.6	0.2	0.2	350	30	70	10,950	25,550	9.2E-04	4.0E-04	4.0E-02	-	2.3E-02	1%	-	-
2-Methylphenol	0.72	1.4	0.6	0.2	0.2	350	30	70	10,950	25,550	3.5E-03	1.5E-03	-	-	-	-	-	-
4-Methylphenol	0.634	1.3	0.6	0.2	0.2	350	30	70	10,950	25,550	3.2E-03	1.4E-03	-	-	-	-	-	-
2,4-Dimethylphenol	0.395	0.79	0.6	0.2	0.2	350	30	70	10,950	25,550	1.9E-03	8.3E-04	-	-	-	-	-	-
Napthalene	0.31	0.62	0.6	0.2	0.2	350	30	70	10,950	25,550	1.5E-03	6.6E-04	-	-	-	-	-	-
2-Methylnapthalene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	-	-	-	-	-
Di-n-butylphthalate	0.0072	0.014	0.6	0.2	0.2	350	30	70	10,950	25,550	3.5E-05	1.5E-05	-	-	-	-	-	-
bis(2-Ethylhexyl)Phthalate	0.043	0.086	0.6	0.2	0.2	350	30	70	10,950	25,550	2.1E-04	9.1E-05	-	-	-	-	-	-

opt1-sa.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 2.7E+00 100%

Excess Lifetime Cancer Risk = 2.9E-05 100%

**INGESTION OF CHEMICALS IN POTABLE GROUNDWATER
HYPOTHETICAL RESIDENCE #2
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI (mg/kg/day) = (CW * IR * EF * ED) / (BW * AT)$$

Non-Carcinogenic Risk:

Hazard Quotient = Chronic Daily Intake (mg/kg/day)/RfD (mg/kg/day)

Hazard Index = Sum (Chemical-Specific Hazard Quotients)

Carcinogenic Risk:

Chemical-Specific Cancer Risk = Chronic Daily Intake (mg/kg/day) * Cancer Slope Factor (mg/kg/day)⁻¹

Excess Lifetime Cancer Risk = Sum (Chemical-Specific Cancer Risk)

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CW = Chemical Concentration in Water (mg/kg)

IR = Water Ingestion Rate (liters/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

Chemical	Chemical Conc. in Water * (mg/l)	Ingest. Rate (l/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
						Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
Methylene Chloride	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-02	7.5E-03	2.3E-03	0%	4.4E-07	1%
1,1-Dichloroethene	0.007	2	350	30	70	10,950	25,550	1.9E-04	8.2E-05	9.0E-03	6.0E-01	2.1E-02	3%	4.9E-05	84%
1,1-Dichloroethane	0.8	2	350	30	70	10,950	25,550	2.2E-02	9.4E-03	1.0E-01	-	2.2E-01	33%	-	-
Cis-1,2-Dichloroethene	0.07	2	350	30	70	10,950	25,550	1.9E-03	8.2E-04	1.0E-02	-	1.9E-01	29%	-	-
Trans-1,2-Dichloroethene	0.10	2	350	30	70	10,950	25,550	2.7E-03	1.2E-03	2.0E-02	-	1.4E-01	20%	-	-
Chloroform	0.00015	2	350	30	70	10,950	25,550	4.1E-06	1.8E-06	1.0E-02	6.1E-03	4.1E-04	0%	1.1E-08	0%
1,2-Dichloroethane	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	9.1E-02	-	-	5.3E-06	9%
1,1,1-Trichloroethane	0.2	2	350	30	70	10,950	25,550	5.5E-03	2.3E-03	9.0E-02	-	6.1E-02	9%	-	-
Trichloroethene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-03	1.1E-02	2.3E-02	3%	6.5E-07	1%
Tetrachloroethylene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	1.0E-02	5.2E-02	1.4E-02	2%	3.1E-06	5%
Hazard Index =												6.7E-01	100%		
Excess Lifetime Cancer Risk =														5.9E-05	100%

*Groundwater concentration equal to MCL or risk-based concentration

opt3-ing.xls

DERMAL CONTACT WITH CHEMICALS IN GROUNDWATER (NONSTEADY STATE MODEL)
HYPOTHETICAL RESIDENCE #2
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES

Calculations:

$$AD \text{ (mg/kg/day)} = (2 * CW * CF * PC * \{ \text{Square root } ((6 * T * ET/\pi)) * ((SA * EF * ED) / (BW * AT)) \})$$

Non-Carcinogenic Risk:

Hazard Quotient = Absorbed Dose (mg/kg/day)/RfD (mg/kg/day)

Hazard Index = Sum (Chemical-Specific Hazard Quotients)

Where:

AD = Absorbed Dose (mg/kg/day)

CW = Chemical Concentration in Water (mg/l)

CF = Volumetric Conversion Factor for Water (1 liter/1,000 cm³)

SA = Skin Surface Available for Contact (cm²)

PC = Chemical-Specific Dermal Permeability Constant (cm/hr)

T = Lag time (hours)

Carcinogenic Risk:

Chemical-Specific Cancer Risk = Absorbed Dose (mg/kg/day) * Cancer Slope Factor (mg/kg/day)⁻¹

Excess Lifetime Cancer Risk = Sum (Chemical-Specific Cancer Risk)

ET = Exposure Time (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

Chemical	Chemical Conc. in Water * (mg/l)	Conv. Factor (1 l/1,000 cm ³)	Permeab. Constant (cm/hour)	T (hours)	Exposure Time (hrs./days)	Skin Surface Area (cm ²)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Absorbed Dose (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
										Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
1,1-Dichloroethene	0.0070	1.0E-03	1.6E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	2.1E-05	9.2E-06	9.0E-03	6.0E-01	2.4E-03	1%	5.5E-06	74%
1,1-Dichloroethane	0.8	1.0E-03	8.9E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.4E-03	5.9E-04	1.0E-01	-	1.4E-02	4%	-	-
Cis-1,2-Dichloroethene	0.070	1.0E-03	-	-	0.2	19,400	350	30	70	10,950	25,550	1.3E-04	5.7E-05	1.0E-02	-	1.3E-02	4%	-	-
Trans-1,2-Dichloroethene	0.1	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-04	8.2E-05	2.0E-02	-	9.6E-03	3%	-	-
1,2-Dichloroethane	0.0050	1.0E-03	5.3E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	5.1E-06	2.2E-06	-	9.1E-02	-	-	2.0E-07	3%
1,1,1-Trichloroethane	0.200	1.0E-03	5.7E-01	5.7E-01	0.2	19,400	350	30	70	10,950	25,550	2.8E-02	1.2E-02	9.0E-02	-	3.1E-01	86%	-	-
Trichloroethene	0.005	1.0E-03	1.6E-02	5.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.4E-06	6.0E-03	1.1E-02	3.2E-03	1%	9.2E-08	1%
Tetrachloroethene	0.005	1.0E-03	4.80E-02	9.0E-01	0.2	19,400	350	30	70	10,950	25,550	7.5E-05	3.2E-05	1.0E-02	5.2E-02	7.5E-03	2%	1.7E-06	22%
Methylene Chloride	0.005	1.0E-03	4.50E-03	2.9E-01	0.2	19,400	350	30	70	10,950	25,550	4.0E-06	1.7E-06	6.0E-02	7.5E-03	6.6E-05	0%	1.3E-08	0%
Chloroform	0.00015	1.0E-03	8.90E-03	4.7E-01	0.2	19,400	350	30	70	10,950	25,550	3.0E-07	1.3E-07	1.0E-02	6.1E-03	3.0E-05	0%	7.9E-10	0%

opt3-der.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 3.6E-01 100%

Excess Lifetime Cancer Risk = 7.5E-06 100%

**INHALATION OF AIRBORNE GROUNDWATER CHEMICALS IN HOUSEHOLD AIR
HYPOTHETICAL RESIDENCE #2
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI (mg/kg/day) = (CA * IR * ER * EF * ED) / BW * AT$$

$$CA = (WHF * CW * f) / (HV * ER * MC)$$

Non-Carcinogenic Risk:

$$Hazard\ Quotient = Chronic\ Daily\ Intake\ (mg/kg/day) / RfD\ (mg/kg/day)$$

$$Hazard\ Index = Sum\ (Chemical-Specific\ Hazard\ Quotients)$$

Carcinogenic Risk:

$$Chemical-Specific\ Cancer\ Risk = Chronic\ Daily\ Intake\ (mg/kg/day) * Cancer\ Slope\ Factor\ (mg/kg/day)^{-1}$$

$$Excess\ Lifetime\ Cancer\ Risk = Sum\ (Chemical-Specific\ Cancer\ Risk)$$

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CA = Chemical Concentration in Household Air (mg/m³)

IR = Inhalation Rate (m³/hour)

ER = Exposure Rate (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

WHF = Water Flow Rate in Whole House/Facility (liter/day)

f = Fraction of Contaminant that Volatilizes (unitless)

ER = Air Exchange Rate (changes/day)

MC = Mixing Coefficient (unitless)

Chemical	Chemical Conc. in Household Air (CA) (mg/m ³)	Inhal Rate (m ³ /hour)	Exposure Frequency (days/year)	Exposure Rate (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
							Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
Methylene Chloride	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	8.6E-01	1.6E-03	3.7E-04	0%	2.2E-07	0%
1,1-Dichloroethene	0.0034	0.6	350	16	30	70	10,950	25,550	4.5E-04	1.9E-04	-	1.8E-01	-	-	3.4E-05	72%
1,1-Dichloroethane	0.4	0.6	350	16	30	70	10,950	25,550	5.3E-02	2.3E-02	1.4E-01	-	3.7E-01	71%	-	-
Cis-1,2-Dichloroethene	0.0340	0.6	350	16	30	70	10,950	25,550	4.5E-03	1.9E-03	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.048	0.6	350	16	30	70	10,950	25,550	6.3E-03	2.7E-03	-	-	-	-	-	-
Chloroform	0.00007	0.6	350	16	30	70	10,950	25,550	9.2E-06	3.9E-06	-	8.1E-02	-	-	3.2E-07	1%
1,2-Dichloroethane	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	2.9E-03	9.1E-02	1.1E-01	21%	1.2E-05	26%
1,1,1-Trichloroethane	0.096	0.6	350	16	30	70	10,950	25,550	1.3E-02	5.4E-03	2.9E-01	-	4.4E-02	8%	-	-
Trichloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	6.0E-03	-	-	8.1E-07	2%
Tetrachloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	2.0E-03	-	-	2.7E-07	1%
Hazard Index =													5.2E-01	100%	Excess Lifetime Cancer Risk =	
															4.8E-05	99%

*Groundwater concentration equal to MCL or risk-based concentration

opt3-ha.xls

**INHALATION OF AIRBORNE GROUNDWATER CHEMICALS IN SHOWER AIR
HYPOTHETICAL RESIDENCE #2
ALL CHEMICALS DETECTED IN ENTIRE STUDY AREA IN AT LEAST FIVE PERCENT OF THE SAMPLES**

Calculations:

$$CDI (mg/kg/day) = [(CA1 * IR * SP) + (CA2 * IR * ASP)] * (EF * ED) / BW * AT$$

$$CA_{Max} = CW * f * Fw * t1 / Va$$

$$CA1 = CA_{Max} / 2$$

$$CA2 = CA_{Max}$$

Non-Carcinogenic Risk:

$$Hazard\ Quotient = Chronic\ Daily\ Intake\ (mg/kg/day) / RfD\ (mg/kg/day)$$

$$Hazard\ Index = Sum\ (Chemical-Specific\ Hazard\ Quotients)$$

Carcinogenic Risk:

$$Chemical-Specific\ Cancer\ Risk = Chronic\ Daily\ Intake\ (mg/kg/day) * Cancer\ Slope\ Factor\ (mg/kg/day)^{-1}$$

$$Excess\ Lifetime\ Cancer\ Risk = Sum\ (Chemical\ Specific\ Cancer\ Risk)$$

Where:

CDI = Chronic Daily Intake (mg/kg/day)

CA1 = Air Concentration During Shower (mg/m³)

IR = Inhalation Rate (m³/hour)

SP = Shower Period (hours/day)

CA2 = Air Concentration After Shower (mg/m³)

ASP = After Shower Period (hours/day)

EF = Exposure Frequency (days/year)

t1 = Time of Shower (hours)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

Non-Carcinogens = ED (years) * 365 days/year

Carcinogens = 70 years * 365 days/year

CW = Average Chemical Concentration in Water (mg/l)

f = Fraction of Contaminant that Volatilizes (unitless)

Fw = Water Flow Rate in Shower (liters/hour)

Va = Bathroom Size (m³)

Chemical	Conc. in Air During Shower (CA1) (mg/m ³)	Conc. in Air After Shower (CA2) (mg/m ³)	Inhal. Rate (m ³ /hr)	Shower Period (hrs/day)	After Shower Period (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Inhalation Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
									Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
1,1-Dichloroethene	0.0540	0.1008	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-04	1.1E-04	-	1.8E-01	-	-	1.9E-05	71%
1,1-Dichloroethane	6.0000	12.000	0.6	0.2	0.2	350	30	70	10,950	25,550	3.0E-02	1.3E-02	1.4E-01	-	2.1E-01	71%	-	-
Cis-1,2-Dichloroethene	0.5040	1.008	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-03	1.1E-03	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.7200	1.4400	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-03	1.5E-03	-	-	-	-	-	-
1,2-Dichloroethane	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	2.9E-03	9.1E-02	6.1E-02	21%	6.9E-06	26%
1,1,1-Trichloroethane	1.460	2.880	0.6	0.2	0.2	350	30	70	10,950	25,550	7.1E-03	3.1E-03	2.9E-01	-	2.5E-02	8%	-	-
Trichloroethylene	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	6.0E-03	-	-	4.6E-07	2%
Methylene Chloride	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	8.6E-01	1.6E-03	2.1E-04	0%	1.2E-07	0%
Chloroform	0.0011	0.0022	0.6	0.2	0.2	350	30	70	10,950	25,550	5.4E-06	2.3E-06	-	8.1E-02	-	-	1.9E-07	1%
Tetrachloroethene	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	2.0E-03	-	-	1.5E-07	1%

opt3-sa.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 2.9E-01 100%

Excess Lifetime Cancer Risk = 2.7E-05 98%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #1

INGESTION PATHWAY

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION												Non-Carcinogenic Risk		Carcinogenic Risk			
Chemical	Chemical Conc. In Water * (mg/l)	Ingest. Rate (l/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk		
						Non-Carc.	Carc.	Non-Carc.	Carc.								
<u>Volatile Organics</u>																	
Vinyl Chloride	0.00100	2	350	30	70	10,950	25,550	2.7E-05	1.2E-05	-	1.9E+00	-	-	2.2E-05	54%		
Chloroethane	0.50000	2	350	30	70	10,950	25,550	1.4E-02	5.9E-03	4.0E-01	-	3.4E-02	10%	-	-		
Methylene Chloride	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-02	7.5E-03	2.3E-03	1%	4.4E-07	1%		
1,1-Dichloroethene	0.00100	2	350	30	70	10,950	25,550	2.7E-05	1.2E-05	9.0E-03	6.0E-01	3.0E-03	1%	7.0E-06	17%		
1,1-Dichloroethane	0.10000	2	350	30	70	10,950	25,550	2.7E-03	1.2E-03	1.0E-01	-	2.7E-02	8%	-	-		
Cis-1,2-Dichloroethene	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	1.0E-02	-	2.7E-02	8%	-	-		
Trans-1,2-Dichloroethene	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	2.0E-02	-	1.4E-02	4%	-	-		
Chloroform	0.00015	2	350	30	70	10,950	25,550	4.1E-06	1.8E-06	1.0E-02	6.1E-03	4.1E-04	0%	1.1E-08	0%		
1,2-Dichloroethane	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	9.1E-02	-	-	5.3E-06	13%		
1,1,1-Trichloroethane	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	9.0E-02	-	3.0E-03	1%	-	-		
Trichloroethene	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-03	1.1E-02	2.3E-02	6%	6.5E-07	2%		
Benzene	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	2.9E-02	-	-	1.7E-06	4%		
Tetrachloroethene	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	1.0E-02	5.20E-02	1.4E-02	4%	3.1E-06	7%		
Toluene	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	2.0E-01	-	1.4E-03	0%	-	-		
Ethylbenzene	0.10000	2	350	30	70	10,950	25,550	2.7E-03	1.2E-03	1.0E-01	-	2.7E-02	8%	-	-		
Xylene	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	2.0E+00	-	1.4E-04	0%	-	-		
<u>Semivolatile Organics</u>																	
1,2-Dichlorobenzene	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	9.0E-02	-	3.0E-03	1%	-	-		
2-Methylphenol	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	5.0E-02	-	5.5E-03	2%	-	-		
4-Methylphenol	0.01000	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	5.0E-03	-	5.5E-02	15%	-	-		
2,4-Dimethylphenol	0.05400	2	350	30	70	10,950	25,550	1.5E-03	6.3E-04	2.0E-02	-	7.4E-02	21%	-	-		
Naphthalene	0.04300	2	350	30	70	10,950	25,550	1.2E-03	5.0E-04	4.0E-02	-	2.9E-02	8%	-	-		
2-Methylnaphthalene	0.00500	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	4.0E-02	-	3.4E-03	1%	-	-		
Di-n-Butylphthalate	0.00100	2	350	30	70	10,950	25,550	2.7E-05	1.2E-05	1.0E-01	-	2.7E-04	0%	-	-		
bis(2-Ethylhexyl)Phthalate	0.00600	2	350	30	70	10,950	25,550	1.6E-04	7.0E-05	2.0E-02	1.4E-02	8.2E-03	2%	9.9E-07	2%		
opt 1 -Ing.xls												Hazard Index = 3.6E-01		100%			
														Excess Lifetime Cancer Risk = 4.2E-05		100%	

opt 1 -ing.xls

Hazard Index = 3.6E-01 100%

Excess Lifetime Cancer Risk = 4.2E-05 100%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #1

DERMAL PATHWAY

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION															Non-Carcinogenic Risk		Carcinogenic Risk		
Chemical	Chemical Conc. in Water (mg/l)	Conv. Factor 1/1,000 cm^3	Permeab. Constant (cm/hour)	T (hours)	Exposure Time (hrs/days)	Skin Surface Area (cm^2)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Absorbed Dose (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor	Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
										Non-Carc.	Carc.	Non-Carc.	Carc.						
<u>Volatile Organics</u>																			
Vinyl Chloride	0.00100	1.0E-03	7.3E-03	2.1E-01	0.2	19,400	350	30	70	10,950	25,550	1.1E-06	4.7E-07	-	1.9E+00	-	-	8.9E-07	22%
Chloroethane	0.50000	1.0E-03	8.0E-03	2.2E-01	0.2	19,400	350	30	70	10,950	25,550	6.2E-04	2.6E-04	4.0E-01	-	1.5E-03	2%	-	-
Methylene Chloride	0.00500	1.0E-03	4.5E-03	2.9E-01	0.2	19,400	350	30	70	10,950	25,550	4.0E-06	1.7E-06	6.0E-02	7.5E-03	6.6E-05	0%	1.3E-08	0%
1,1-Dichloroethene	0.00100	1.0E-03	1.6E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	3.1E-06	1.3E-06	9.0E-03	6.0E-01	3.4E-04	0%	7.9E-07	19%
1,1-Dichloroethane	0.10000	1.0E-03	8.9E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.7E-04	7.4E-05	1.0E-01	-	1.7E-03	2%	-	-
Cis-1,2-Dichloroethene	0.01000	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.2E-06	1.0E-02	-	1.9E-03	2%	-	-
Trans-1,2-Dichloroethene	0.01000	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.2E-06	2.0E-02	-	9.6E-04	1%	-	-
Chloroform	0.00015	1.0E-03	8.9E-03	4.7E-01	0.2	19,400	350	30	70	10,950	25,550	3.0E-07	1.3E-07	1.0E-02	6.1E-03	3.0E-05	0%	7.9E-10	0%
1,2-Dichloroethane	0.00500	1.0E-03	5.3E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	5.1E-06	2.2E-06	-	9.1E-02	-	-	-	5%
1,1,1-Trichloroethane	0.01000	1.0E-03	5.7E-01	5.7E-01	0.2	19,400	350	30	70	10,950	25,550	1.4E-03	6.1E-04	9.0E-02	-	1.6E-02	20%	2.0E-07	2%
Trichloroethene	0.00500	1.0E-03	1.6E-02	5.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.4E-06	6.0E-03	1.1E-02	3.2E-03	4%	9.2E-08	2%
Benzene	0.00500	1.0E-03	2.1E-02	2.6E-01	0.2	19,400	350	30	70	10,950	25,550	1.8E-05	7.5E-06	-	2.9E-02	-	-	2.2E-07	5%
Tetrachloroethene	0.00500	1.0E-03	4.80E-02	9.0E-01	0.2	19,400	350	30	70	10,950	25,550	7.5E-05	3.2E-05	1.0E-02	5.20E-02	7.5E-03	10%	1.7E-06	40%
Toluene	0.01000	1.0E-03	4.50E-02	3.2E-01	0.2	19,400	350	30	70	10,950	25,550	8.4E-05	3.6E-05	2.0E-01	-	4.2E-04	1%	-	-
Ethylbenzene	0.10000	1.0E-03	7.4E-02	3.9E-01	0.2	19,400	350	30	70	10,950	25,550	1.5E-03	6.5E-04	1.0E-01	-	1.5E-02	20%	-	-
Xylene	0.01000	1.0E-03	8.0E-02	3.9E-01	0.2	19,400	350	30	70	10,950	25,550	1.6E-04	7.0E-05	2.0E+00	-	8.2E-05	0%	-	-
<u>Semivolatile Organics</u>																			
1,2-Dichlorobenzene	0.01000	1.0E-03	6.1E-02	6.9E-01	0.2	19,400	350	30	70	10,950	25,550	1.7E-04	7.1E-05	9.0E-02	-	1.8E-03	2%	-	-
2-Methylphenol	0.01000	1.0E-03	5.5E-03	3.3E-01	0.2	19,400	350	30	70	10,950	25,550	1.0E-05	4.4E-06	5.0E-02	-	2.1E-04	0%	-	-
4-Methylphenol	0.01000	1.0E-03	5.5E-03	3.3E-01	0.2	19,400	350	30	70	10,950	25,550	1.0E-05	4.4E-06	5.0E-03	-	2.1E-03	3%	-	-
2,4-Dimethylphenol	0.05400	1.0E-03	5.5E-03	4.9E-01	0.2	19,400	350	30	70	10,950	25,550	6.8E-05	2.9E-05	2.0E-02	-	3.4E-03	4%	-	-
Naphthalene	0.04300	1.0E-03	6.9E-02	5.3E-01	0.2	19,400	350	30	70	10,950	25,550	7.1E-04	3.0E-04	4.0E-02	-	1.8E-02	23%	-	-
2-Methylnaphthalene	0.00500	1.0E-03	4.0E-02	1.1E-01	0.2	19,400	350	30	70	10,950	25,550	2.2E-05	9.3E-06	4.0E-02	-	5.4E-04	1%	-	-
Di-n-Butylphthalate	0.00100	1.0E-03	3.3E-02	4.3E+00	0.2	19,400	350	30	70	10,950	25,550	2.2E-05	9.6E-06	1.0E-01	-	2.2E-04	0%	-	-
bis(2-Ethylhexyl)Phthalate	0.00600	1.0E-03	4.8E-03	2.1E+01	0.2	19,400	350	30	70	10,950	25,550	4.3E-05	1.9E-05	2.0E-02	1.4E-02	2.2E-03	3%	2.6E-07	6%
opt1-der.xls															Hazard Index = 7.7E-02		100%		

opt1-der.xls

Hazard Index = 7.7E-02 100%

Excess Lifetime Cancer Risk = 4.1E-06 102%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #1

INHALATION PATHWAY (HOUSEHOLD)

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION													Non-Carcinogenic Risk		Carcinogenic Risk		
Chemical	Chemical Conc. in Household Air (CA)	Inhal Rate	Exposure Frequency	Exposure Rate	Exposure Duration	Body Weight	Averaging Time (days)		Chronic Daily Intake (mg/kg/day)		Inhalation Reference Dose (RfD)	Cancer Slope Factor	Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk	
	(mg/m ³)	(m ³ /hour)	(days/year)	(hours/day)	(years)	(kg)	Non-Carc.	Carc.	Non-Carc.	Carc.	(mg/kg/day)	mg/kg/day)-1					
Vinyl Chloride	0.0005	0.6	350	16	30	70	10,950	25,550	6.3E-05	2.7E-05	-	3.0E-01	-	-	8.1E-06	26.4%	
Chloroethane	0.2400	0.6	350	16	30	70	10,950	25,550	3.2E-02	1.4E-02	2.86E+00	-	1.1E-02	2.8%	-	-	
Methylene Chloride	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	8.57E-01	1.6E-03	3.7E-04	0.1%	2.2E-07	0.7%	
1,1-Dichloroethene	0.0005	0.6	350	16	30	70	10,950	25,550	6.3E-05	2.7E-05	-	1.8E-01	-	-	4.7E-06	15.4%	
1,1-Dichloroethane	0.0480	0.6	350	16	30	70	10,950	25,550	6.3E-03	2.7E-03	1.43E-01	-	4.4E-02	11.2%	-	-	
Cis-1,2-Dichloroethene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-	
Trans-1,2-Dichloroethene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-	
Chloroform	0.0001	0.6	350	16	30	70	10,950	25,550	9.5E-06	4.1E-06	-	8.1E-02	-	-	3.3E-07	1.1%	
1,2-Dichloroethane	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	2.90E-03	9.1E-02	1.1E-01	27.7%	1.2E-05	40.1%	
1,1,1-Trichloroethane	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	2.9E-01	-	2.2E-03	0.6%	-	-	
Trichloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	6.0E-03	-	-	8.1E-07	2.6%	
Benzene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	1.71E-03	2.9E-02	1.8E-01	47.0%	3.9E-06	12.8%	
Tetrachloromethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	2.0E-03	-	-	2.7E-07	0.9%	
Toluene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	1.14E-01	-	5.5E-03	1.4%	-	-	
Ethylbenzene	0.0480	0.6	350	16	30	70	10,950	25,550	6.3E-03	2.7E-03	2.86E-01	-	2.2E-02	5.6%	-	-	
Xylene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	2.00E-01	-	3.2E-03	0.8%	-	-	
Semi-volatile Organics													-	0.0%	-	-	
1,2-Dichlorobenzene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	5.71E-02	-	1.1E-02	2.8%	-	-	
2-Methylphenol	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-	
4-Methylphenol	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-	
2,4-Dimethylphenol	0.0259	0.6	350	16	30	70	10,950	25,550	3.4E-03	1.5E-03	-	-	-	-	-	-	
Naphthalene	0.0206	0.6	350	16	30	70	10,950	25,550	2.7E-03	1.2E-03	-	-	-	-	-	-	
2-Methylnaphthalene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	-	-	-	-	-	
Di-n-Butylphthalate	0.0029	0.6	350	16	30	70	10,950	25,550	3.8E-04	1.6E-04	-	-	-	-	-	-	
bis(2-Ethylhexyl)Phthalate	0.0029	0.6	350	16	30	70	10,950	25,550	3.8E-04	1.6E-04	-	-	-	-	-	-	
opt-1-halxls													-	0.0%	-	-	
													Hazard Index =	3.9E-01	100%	-	-
*Groundwater concentration equal to MCL or risk-based concentration																	

opt1-ha.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 3.9E-01 100%

Excess Lifetime Cancer Risk = 3.1E-05 100%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #1

INHALATION PATHWAY (SHOWER)

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION															Non-Carcinogenic Risk		Carcinogenic Risk	
Chemical	Conc. in Air During Shower (CA1)	Conc. in Air After Shower (CA2)	Inhal. Rate (m³/hr)	Shower Period (hrs/day)	After Shower Period (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Inhalation Cancer Slope Factor	Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
	(mg/m³)	(mg/m³)							Non-Carc.	Carc.	Non-Carc.	Carc.						
Vinyl Chloride	0.007	0.014	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-05	1.5E-05	-	3.0E-01	-	-	4.6E-06	36%
Chloromethane	3.600	7.200	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-02	7.6E-03	2.9E+00	-	6.2E-03	3%	-	-
Methylene Chloride	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	8.6E-01	1.6E-03	2.1E-04	0%	1.2E-07	1%
1,1-Dichloroethene	0.007	0.014	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-05	1.5E-05	-	1.8E-01	-	-	2.7E-06	21%
1,1-Dichloroethene	0.720	1.440	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-03	1.5E-03	1.4E-01	-	2.5E-02	11%	-	-
Cis-1,2-Dichloroethene	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-
Chloroform	0.001	0.002	0.6	0.2	0.2	350	30	70	10,950	25,550	5.3E-06	2.3E-06	-	8.1E-02	-	-	1.8E-07	1%
1,2-Dichloroethane	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	2.9E-03	9.1E-02	6.1E-02	28%	6.9E-06	55%
1,1,1-Trichloroethane	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	2.9E-01	-	1.2E-03	1%	-	-
Trichloroethylene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	6.0E-03	-	-	4.6E-07	4%
Benzene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	1.7E-03	2.9E-02	1.0E-01	48%	2.2E-06	18%
Tetrachloroethene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	2.0E-03	-	-	1.5E-07	1%
Toluene	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	1.1E-01	-	3.1E-03	1%	-	-
Ethylbenzene	0.720	1.440	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-03	1.5E-03	2.9E-01	-	1.2E-02	6%	-	-
Xylene	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	2.0E-01	-	1.8E-03	1%	-	-
Semivolatile Organics																		
1,2-Dichlorobenzene	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	4.0E-02	-	8.9E-03	4%	-	-
2-Methylphenol	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-
4-Methylphenol	0.072	0.144	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-
2,4-Dimethylphenol	0.395	0.790	0.6	0.2	0.2	350	30	70	10,950	25,550	1.9E-03	8.3E-04	-	-	-	-	-	-
Naphthalene	0.310	0.619	0.6	0.2	0.2	350	30	70	10,950	25,550	1.5E-03	6.5E-04	-	-	-	-	-	-
2-Methylnaphthalene	0.036	0.072	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	-	-	-	-	-
Di-n-butylphthalate	0.007	0.014	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-05	1.5E-05	-	-	-	-	-	-
bis(2-Ethylhexyl)Phthalate	0.043	0.086	0.6	0.2	0.2	350	30	70	10,950	25,550	2.1E-04	9.1E-05	-	-	-	-	-	-
opt1-sa.xls															Hazard Index =		2.2E-01 100%	
*Groundwater concentration equal to MCL or risk-based concentration																		

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER

Household Air (CA) Exposure Point Concentrations of Groundwater Origin							
Chemical of Concern	WHF (l/day)	CW (mg/l)	f (unitless)	HV (m^3)	ER (day^-1)	MC (unitless)	CA (mg/m^3)
<u>Volatile Organics</u>							
Vinyl Chloride	720	0.001	0.9	180	15	0.5	0.0005
Chloroethane	720	0.500	0.9	180	15	0.5	0.24
Methylene Chloride	720	0.005	0.9	180	15	0.5	0.0024
1,1-Dichloroethene	720	0.001	0.9	180	15	0.5	0.0005
1,1-Dichloroethane	720	0.100	0.9	180	15	0.5	0.0
Cis-1,2-Dichloroethene	720	0.010	0.9	180	15	0.5	0.005
Trans-1,2-Dichloroethene	720	0.010	0.9	180	15	0.5	0.005
Chloroform	720	0.000	0.9	180	15	0.5	0.00007
1,2-Dichloroethane	720	0.005	0.9	180	15	0.5	0.0024
1,1,1-Trichloroethane	720	0.010	0.9	180	15	0.5	0.005
Trichloroethylene	720	0.005	0.9	180	15	0.5	0.0024
Benzene	720	0.005	0.9	180	15	0.5	0.0024
Tetrachloroethene	720	0.005	0.9	180	15	0.5	0.0024
Toluene	720	0.010	0.9	180	15	0.5	0.00
Ethylbenzene	720	0.100	0.9	180	15	0.5	0.05
Xylene	720	0.010	0.9	180	15	0.5	0.0
<u>Semivolatile Organics</u>							
1,2-Dichlorobenzene	720	0.010	0.9	180	15	0.5	0.005
2-Methylphenol	720	0.010	0.9	180	15	0.5	0.005
4-Methylphenol	720	0.010	0.9	180	15	0.5	0.005
2,4-Dimethylphenol	720	0.054	0.9	180	15	0.5	0.026
Naphthalene	720	0.043	0.9	180	15	0.5	0.021
2-Methylnaphthalene	720	0.005	0.9	180	15	0.5	0.0024
Di-n-butylphthalate(1)	720	0.001	0.9	180	15	0.5	0.0029
bis(2-Ethylhexyl)Phtha	720	0.006	0.9	180	15	0.5	0.0029

opt1-ep.xls

(1) Risk-based concentration for di-n-octyl phthalate

CA = (WHF * CW * f) / (HV * ER * MC)

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

SHOWER AIR CONCENTRATIONS						CA max or	
Chemical of Concern	CW	f	Fw	t1	Va	CA 1 (*)	CA 2 (**)
<u>Volatile Organics</u>							
Vinyl Chloride	0.001	0.9	800	0.2	10	0.0072	0.014
Chloroethane	0.500	0.9	800	0.2	10	3.6000	7.2
Methylene Chloride	0.005	0.9	800	0.2	10	0.0360	0.072
1,1-Dichloroethene	0.001	0.9	800	0.2	10	0.0072	0.01
1,1-Dichloroethane	0.100	0.9	800	0.2	10	0.720	1
Cis-1,2-Dichloroethene	0.010	0.9	800	0.2	10	0.072	0.1
Trans-1,2-Dichloroethene	0.010	0.9	800	0.2	10	0.072	0.1
Chloroform	0.000	0.9	800	0.2	10	0.0011	0.0022
1,2-Dichloroethane	0.005	0.9	800	0.2	10	0.036	0.072
1,1,1-Trichloromethane	0.010	0.9	800	0.2	10	0.0720	0.1
Trichloromethylene	0.005	0.9	800	0.2	10	0.0360	0.072
Benzene	0.005	0.9	800	0.2	10	0.036	0.072
Tetrachloroethene	0.005	0.9	800	0.2	10	0.036	0.072
Toluene	0.010	0.9	800	0.2	10	0.0720	0
Ethylbenzene	0.100	0.9	800	0.2	10	0.7200	1
Xylene	0.010	0.9	800	0.2	10	0.0720	0
<u>Semivolatile Organics</u>							
1,2-Dichlorobenzene	0.010	0.9	800	0.2	10	0.0720	0.144
2-Methylphenol	0.010	0.9	800	0.2	10	0.0720	0.1
4-Methylphenol	0.010	0.9	800	0.2	10	0.072	0.1
2,4-Dimethylphenol	0.054	0.9	800	0.2	10	0.395	0.79
Naphthalene	0.043	0.9	800	0.2	10	0.310	0.62
2-Methylnaphthalene	0.005	0.9	800	0.2	10	0.036	0.072
Di-n-butylphthalate	0.001	0.9	800	0.2	10	0.0072	0.014
bis(2-Ethylhexyl)Phtha	0.006	0.9	800	0.2	10	0.0432	0.086

opt1-ep.xls

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #2

INGESTION PATHWAY

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

Chemical	Chemical Conc. in Water * (mg/l)	Ingest. Rate (l/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor (mg/kg/day) ⁻¹	Non-Carcinogenic Risk		Carcinogenic Risk	
						Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
Methylene Chloride	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-02	7.5E-03	2.3E-03	1%	4.4E-07	1%
1,1-Dichloroethene	0.004	2	350	30	70	10,950	25,550	1.1E-04	4.7E-05	9.0E-03	6.0E-01	1.2E-02	4%	2.8E-05	75%
1,1-Dichloroethane	0.700	2	350	30	70	10,950	25,550	1.9E-02	8.2E-03	1.0E-01	-	1.9E-01	67%	-	-
Cis-1,2-Dichloroethene	0.01	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	1.0E-02	-	2.7E-02	10%	-	-
Trans-1,2-Dichloroethene	0.01	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	2.0E-02	-	1.4E-02	5%	-	-
Chloroform	0.00015	2	350	30	70	10,950	25,550	4.1E-06	1.8E-06	1.0E-02	6.1E-03	4.1E-04	0%	1.1E-08	0%
1,2-Dichloroethane	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	-	9.1E-02	-	-	5.3E-06	14%
1,1,1-Trichloroethane	0.01	2	350	30	70	10,950	25,550	2.7E-04	1.2E-04	9.0E-02	-	3.0E-03	1%	-	-
Trichloroethene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	6.0E-03	1.1E-02	2.3E-02	8%	6.5E-07	2%
Tetrachloroethylene	0.005	2	350	30	70	10,950	25,550	1.4E-04	5.9E-05	1.0E-02	5.2E-02	1.4E-02	5%	3.1E-06	8%

opt3-ing.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 2.9E-01 100%

Excess Lifetime Cancer Risk = 3.8E-05 100%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #2

DERMAL PATHWAY

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

Chemical	Chemical Conc. in Water * (mg/l)	Conv. Factor 1/1,000 cm ³	Permeab. Constant (cm/hour)	T (hours)	Exposure Time (hrs./days)	Skin Surface Area (cm ²)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Absorbed Dose (mg/kg/day)		Oral Reference Dose (RfD) (mg/kg/day)	Oral Cancer Slope Factor	Non-Carcinogenic Risk		Carcinogenic Risk	
										Non-Carc.	Carc.	Non-Carc.	Carc.			Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk
1,1-Dichloroethene	0.0040	1.0E-03	1.6E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.2E-05	5.3E-06	9.0E-03	6.0E-01	1.4E-03	3%	3.2E-06	62%
1,1-Dichloroethane	0.7	1.0E-03	8.9E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.2E-03	5.2E-04	1.0E-01	-	1.2E-02	28%	-	-
Cis-1,2-Dichloroethene	0.010	1.0E-03	-	-	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.2E-06	1.0E-02	-	1.9E-03	4%	-	-
Trans-1,2-Dichloroethene	0.0	1.0E-03	1.0E-02	3.4E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.2E-06	2.0E-02	-	9.6E-04	2%	-	-
1,2-Dichloroethane	0.0050	1.0E-03	5.3E-03	3.5E-01	0.2	19,400	350	30	70	10,950	25,550	5.1E-06	2.2E-06	-	9.1E-02	-	-	2.0E-07	4%
1,1,1-Trichloroethane	0.010	1.0E-03	5.7E-01	5.7E-01	0.2	19,400	350	30	70	10,950	25,550	1.4E-03	6.1E-04	9.0E-02	-	1.6E-02	37%	-	-
Trichloroethene	0.005	1.0E-03	1.6E-02	5.5E-01	0.2	19,400	350	30	70	10,950	25,550	1.9E-05	8.4E-06	6.0E-03	1.1E-02	3.2E-03	8%	9.2E-08	2%
Tetrachloroethene	0.005	1.0E-03	4.80E-02	9.0E-01	0.2	19,400	350	30	70	10,950	25,550	7.5E-05	3.2E-05	1.0E-02	5.2E-02	7.5E-03	17%	1.7E-06	33%
Methylene Chloride	0.005	1.0E-03	4.50E-03	2.9E-01	0.2	19,400	350	30	70	10,950	25,550	4.0E-06	1.7E-06	6.0E-02	7.5E-03	6.6E-05	0%	1.3E-08	0%
Chloroform	0.00015	1.0E-03	8.90E-03	4.7E-01	0.2	19,400	350	30	70	10,950	25,550	3.0E-07	1.3E-07	1.0E-02	6.1E-03	3.0E-05	0%	7.9E-10	0%

opt3-der.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 4.3E-02 100%

Excess Lifetime Cancer Risk = 5.1E-06 100%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #2

INHALATION PATHWAY (HOUSEHOLD)

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

Chemical	Chemical Conc. In Household Air (CA)												Non-Carcinogenic Risk		Carcinogenic Risk	
	Household Air (CA) (mg/m ³)	Inhal Rate (m ³ /hour)	Exposure Frequency (days/year)	Exposure Rate (hours/day)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Cancer Slope Factor (mg/kg/day) ⁻¹	Hazard Quotient	%	Chemical Specific Cancer Risk	%
							Non-Carc.	Carc.	Non-Carc.	Carc.						
Methylene Chloride	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	8.6E-01	1.6E-03	3.7E-04	0%	2.2E-07	1%
1,1-Dichloroethene	0.0019	0.6	350	16	30	70	10,950	25,550	2.5E-04	1.1E-04	-	1.8E-01	-	-	1.9E-05	59%
1,1-Dichloroethane	0.3360	0.6	350	16	30	70	10,950	25,550	4.4E-02	1.9E-02	1.4E-01	-	3.1E-01	74%	-	-
Cis-1,2-Dichloroethene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-
Trans-1,2-Dichloroethene	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	-	-	-	-	-	-
Chloroform	0.0001	0.6	350	16	30	70	10,950	25,550	9.5E-06	4.1E-06	-	8.1E-02	-	-	3.3E-07	1%
1,2-Dichloroethane	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	2.9E-03	9.1E-02	1.1E-01	26%	1.2E-05	37%
1,1,1-Trichloroethane	0.0048	0.6	350	16	30	70	10,950	25,550	6.3E-04	2.7E-04	2.9E-01	-	2.2E-03	1%	-	-
Trichloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	6.0E-03	-	-	8.1E-07	2%
Tetrachloroethylene	0.0024	0.6	350	16	30	70	10,950	25,550	3.2E-04	1.4E-04	-	2.0E-03	-	-	2.7E-07	1%

opt3-ha.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 4.2E-01 100%

Excess Lifetime Cancer Risk = 3.3E-05 99%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

HYPOTHETICAL RESIDENCE #2

INHALATION PATHWAY (SHOWER)

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION															Non-Carcinogenic Risk		Carcinogenic Risk			
Chemical	Conc. in Air During Shower (CA1)	Conc. in Air After Shower (CA2)	Inhal. Rate (m ³ /hr)	Shower Period (hrs/day)	After Shower Period (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)		Chronic Daily Intake (CDI) (mg/kg/day)		Inhalation Reference Dose (RfD) (mg/kg/day)	Inhalation Cancer Slope Factor	Hazard Quotient	% Risk	Chemical Specific Cancer Risk	% Risk		
	(mg/m ³)	(mg/m ³)							Non-Carc.	Carc.	Non-Carc.	Carc.								
1,1-Dichloroethene	0.0288	0.0576	0.6	0.2	0.2	350	30	70	10,950	25,550	1.4E-04	6.1E-05	-	1.8E-01	-	-	1.1E-05	58%		
1,1-Dichloroethane	5.0400	10.0800	0.6	0.2	0.2	350	30	70	10,950	25,550	2.5E-02	1.1E-02	1.4E-01	-	1.7E-01	74%	-	-		
Cis-1,2-Dichloroethene	0.0720	0.1440	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-		
Trans-1,2-Dichloroethene	0.0720	0.1440	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	-	-	-	-	-	-		
1,2-Dichloroethane	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	2.9E-03	9.1E-02	6.1E-02	26%	6.9E-06	37%		
1,1,1-Trichloroethane	0.0720	0.1440	0.6	0.2	0.2	350	30	70	10,950	25,550	3.6E-04	1.5E-04	2.9E-01	-	1.2E-03	1%	-	-		
Trichloroethylene	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	6.0E-03	-	-	4.6E-07	2%		
Methylene Chloride	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	8.6E-01	1.6E-03	2.1E-04	0%	1.2E-07	1%		
Chloroform	0.0011	0.0022	0.6	0.2	0.2	350	30	70	10,950	25,550	5.3E-06	2.3E-06	-	8.1E-02	-	-	1.8E-07	1%		
Tetrachloroethene	0.0360	0.0720	0.6	0.2	0.2	350	30	70	10,950	25,550	1.8E-04	7.6E-05	-	2.0E-03	-	-	1.5E-07	1%		
opt3-sa.xls															Hazard Index =		2.4E-01	100%		
*Groundwater concentration equal to MCL or risk-based concentration																				

opt3-sa.xls

*Groundwater concentration equal to MCL or risk-based concentration

Hazard Index = 2.4E-01 100%

Excess Lifetime Cancer Risk = 1.8E-05 98%

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER

Household Air (CA) Exposure Point Concentrations of Groundwater Origin							
Chemical of Conce	WHF (l/day)	CW (mg/l)	f (unitless)	HV (m^3)	ER (day^-1)	MC (unitless)	CA (mg/m^3)
<i><u>Volatile Organics</u></i>							
Methylene Chlori	720	0.005	0.9	180	15	0.5	0.0024
1,1-Dichloroether	720	0.004	0.9	180	15	0.5	0.0019
1,1-Dichloroetha	720	0.7	0.9	180	15	0.5	0.3
Cis-1,2-Dichloro	720	0.01	0.9	180	15	0.5	0.005
Trans-1,2-Dichlo	720	0.01	0.9	180	15	0.5	0.005
Chloroform	720	0.00015	0.9	180	15	0.5	0.00007
1,2-Dichloroetha	720	0.005	0.9	180	15	0.5	0.0024
1,1,1-Trichloroet	720	0.01	0.9	180	15	0.5	0.005
Trichloroethylene	720	0.005	0.9	180	15	0.5	0.0024
Tertachloroethen	720	0.005	0.9	180	15	0.5	0.0024

opt1-ep.xls

BACKUP FOR ALTERNATIVE CLEANUP LEVELS

EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF CONCERN IN GROUNDWATER

Shower Air Exposure Point Concentrations of Groundwater Origin (During and After Showering)							
Chemical of Conce	CW	f	Fw	tl	Va	CA 1 (*)	CA max of CA 2 (**)
<u>Volatiles Organics</u>							
Methylene Chlori	0.005	0.9	800	0.2	10	0.0360	0.072
1,1-Dichloroether	0.004	0.9	800	0.2	10	0.0288	0.06
1,1-Dichloroetha	0.7	0.9	800	0.2	10	5.040	10
Cis-1,2-Dichloro	0.01	0.9	800	0.2	10	0.072	0.1
Trans-1,2-Dichlo	0.01	0.9	800	0.2	10	0.072	0.1
Chloroform	0.00015	0.9	800	0.2	10	0.0011	0.0022
1,2-Dichloroetha	0.005	0.9	800	0.2	10	0.036	0.072
1,1,1-Trichloroet	0.01	0.9	800	0.2	10	0.0720	0.1
Trichloroethylen	0.005	0.9	800	0.2	10	0.0360	0.072
Tertachloroethen	0.005	0.9	800	0.2	10	0.036	0.072

opt1-ep.xls